10191/3675
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	Stephan SIMON et al.
International Application	:	PCT/DE03/01409
International Filing Date	:	02 May 2003
Priority Date	:	07 May 2002 11 December 2002
Serial No.	:	10/533,778
For	:	METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT

Commissioner For Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Attention: PCT Legal Department

PETITION FOR REVIVAL OF AN APPLICATION FOR PATENT ABANDONED UNINTENTIONALLY UNDER 37 CFR 1.137(b)

SIR:

In response to the Communication mailed July 19, 2005, applicant has noted that the above-identified application became abandoned for failure to enter the national stage on the appropriate date. The abandonment date of this application is November 8, 2004.

1. The entire delay in timely entering the national stage in the United States under 37 U.S.C. 371 was unintentional.

Please charge the amount of $1,500.00 for payment of the fee for filing this Petition to Revive under 37 C.F.R. §1.137(b) and any other additional fees to Deposit Account 11-0600.

 EU 323025984 US

2. This petition is accompanied by the following items which were originally filed on May 4, 2005:

a. Transmittal Letter to the U.S. Designated/Elected Office (Form PTO 1390) requesting entry in the U.S. national stage and the appropriate fee;

b. Preliminary Amendment;

c. English translation of International Application with drawings;

d. Substitute Specification and Marked-Up copy thereof

e. Declaration & Power of Attorney;

f. English translation of International Search Report;

g. PCT/RO/101;

h. Information Disclosure Statement and PTO-1449; and

i. Assignment and Recordation Sheet..

Applicants' entire delay in timely filing the U.S. National Phase application was unintentional.

A favorable decision on this Petition is respectfully requested.

Respectfully submitted,

Date: July 29, 2005

Gerard A. Messina, Reg. No. 35,952
For Richard L. Mayer, Reg. No. 22,490

KENYON & KENYON
One Broadway
New York, New York 10004
212 425-7200
Customer No. 26646

1025587-1

FORM PTO-1390 (REV. 10-2003) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER
20191/367[illegible]

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED:
PCT/DE03/01409	**(02.05.03)** **02 May 2003**	**(07.05.02)** **(11.12.02)** **07 May 2002** **11 Dec. 2002**

TITLE OF INVENTION

METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT

APPLICANT(S) FOR DO/EO/US

SIMON, Stephan; IGNACZAK, Brad; and LYONS, Robert

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A preliminary amendment.
14. ☐ An Application Data Sheet under 37 CFR 1.76.
15. ☒ A substitute specification.
16. ☐ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.2 and 37 CFR 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: International Search Report (translated) and PCT/RO/101.

EXPRESS MAIL NO.: EV 320194842 US
NY01 964031 v1

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTOR S DOCKET NUMBER
	PCT/I[illegible]/01409	10191/3675

The following fees are submitted:			
21 ☒ **Basic National Fee**	$ 300.00	$	--
22.☐ **Examination Fee** – If International preliminary exam report prepared by USPTO and all claims satisfy provisions of PCT Article 33/(1)-(4)........	$ 100.00	$	
☒ Examination Fee - All other situations	$ 200.00	$	
23. ☐ **Search Fee** – Search fee (37 CFR 1.445(a)(2) has been paid on the international application to the USPTO as ISA	$ 100.00	$	
☒ International Search Report prepared and provided to the Office........	$ 400.00	$	
☐ Search Fee – All other situations	$ 500.00	$	
TOTAL OF ABOVE CALCULATIONS		$ 900.00	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing on computer program listing filed in an electronic medium). The fee is **$250** for each additional 50 sheets of paper or fraction thereof.					
Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round up to a whole number)	RATE		
-100	/50=		x **$250**	$	
Surcharge of **$130.00** for furnishing the oath or declaration later than 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	17 - 20 =		x **$50.00**	$	
Independent Claims	1 - 3 =		x **$200.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$360.00**	$	
			TOTAL OF ABOVE CALCULATIONS =	$ 900.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.					
			SUBTOTAL =	$ 900.00	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
			TOTAL NATIONAL FEE =	$ 900.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property				$	
			TOTAL FEES ENCLOSED =	$ 900.00	
				Amount to be refunded:	$
				Amount to be charged	$ 900.00

a. ☐ A check in the amount of $__________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$900.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
KENYON & KENYON
One Broadway
New York, New York 10004
CUSTOMER NO. 26646

By [signature] Reg No 35,952
SIGNATURE
Richard L. Mayer (Reg. No. 22,490)
NAME
5/4/05
DATE

EXPRESS MAIL NO.: EV 320194842 US
NY01 964031 v1

[10191/3675]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	Stephan SIMON et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT
Art Unit	:	To Be Assigned
Examiner	:	To Be Assigned

Mail Stop PCT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT AND 37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims which begins on page 3 of this paper.

Remarks begin on page 5 of this paper.

AMENDMENTS TO THE SPECIFICATION:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior version, and listings, of claims in the application:

Listing of Claims:

Claims 1-11 (canceled).

12. (New) A method for determining an accident risk of a first object (48, 52) with at least one second object (49; 53), comprising: determining the accident risk as a function of a collision probability and a hazard probability of the at least one second object (49, 53) in a predefined region (50, 55), and determining the collision probability and the hazard probability as a function of motions of the first and at least one second object.

13. (New) The method according to Claim 12, wherein an object class of the first and at least one second object are taken into account in determining the collision probability and the hazard probability.

14. (New) The method according to Claim 12, wherein the motion and the object class of the at least one second object are determined by way of a sensor suite (1), and the motion and the object class of the first object (48, 52) are retrieved from at least one data source.

15. (New) The method according to Claim 13, wherein the motion and the object class of the at least one second object are determined by way of a sensor suite (1), and the motion and the object class of the first object (48, 52) are retrieved from at least one data source.

16. (New) The method according to Claim 12, wherein the motion of the first object (48, 52) is defined by way of at least one current position and its velocity.

17. (New) The method according to Claim 13, wherein the motion of the first object (48, 52) is defined by way of at least one current position and its velocity.

18. (New) The method according to Claim 12, wherein the motion of the at least one second object (49, 53) is defined by way of at least one current position.

19. (New) The method according to Claim 13, wherein the motion of the at least one second object (49, 53) is defined by way of at least one current position.

20. (New) The method according to Claim 14, wherein the motion of the at least one second object (49, 53) is defined by way of at least one current position.

21. (New) The method according to Claim 16, wherein the motion of the at least one second object (49, 53) is defined by way of at least one current position.

22. (New) The method according to Claim 16, wherein the motion of the first object is additionally determined by way of at least one of its first longitudinal acceleration, first transverse acceleration, a first rotation angle and a first steering angle.

23. (New) The method according to Claim 18, wherein the motion of the at least one second object is additionally determined by way of its velocity relative to the first object and/or a second longitudinal acceleration and/or a second transverse acceleration and/or a second rotation angle.

24. (New) The method according to Claim 22, wherein environmental influences and/or a respective driving behavior are taken into account in determining the respective motion.

25. (New) The method according to Claim 23, wherein environmental influences and/or a respective driving behavior are taken into account in determining the respective motion.

26. (New) The method according to Claim 12, wherein at least one of an indication (4) and at least one signal to an actuator suite (35) are generated as a function of the accident risk.

27. (New) A method of using a control unit in a vehicle constituting an object in the method according to Claim 12.

28. (New) A method of using a restraint system (5) in a vehicle constituting an object in the method according to Claim 12.

Remarks

This Preliminary Amendment cancels without prejudice original PCT claims 1-11 in the underlying PCT Application No. PCT/DE03/01409, and adds new claims 12-28. The new claims conform to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(ii) and § 1.125(c), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE03/01409 includes an International Search Report, dated September 19, 2003. The Search Report includes a list of documents that were uncovered in the underlying PCT Application. A copy of the Search Report accompanies this Preliminary Amendment.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,
KENYON & KENYON

Dated: 5/4/05

By: ~~Richard L. Mayer~~ By: [illegible] RN 35,952

Richard L. Mayer
(Reg. No. 22,490)

One Broadway
New York, NY 10004
(212) 425-7200

CUSTOMER NO. 26646

METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT

Background Information

The present invention proceeds from a method for determining an accident risk of a first object with at least one second object, according to the species defined in the independent claim.

Advantages of the Invention

The method according to the present invention for determining an accident risk of a first object with at least one second object, having the features of the independent claim, has the advantage that the collision probability of an own vehicle with one or more other objects can be determined. These collision probabilities can be evaluated, for example, by a control unit for restraint systems or other safety systems and used, even before the collision occurs, to initiate actions that mitigate the effects of the collision or in fact prevent it.

The method according to the present invention requires the detection of objects, and determines the status of the own object and of the other objects in the vicinity, the collision probability and a hazard probability between the own object and the other objects being determined. An accident risk is then derived therefrom. The "hazard probability" is understood here as a probability of at least a near miss; this means that

a region is drawn around the own object, and the probability that other objects might enter that region around the own object is calculated. The collision itself is thus also detected from the hazard probability. The "collision probability," on the other hand, means that an overlap or crash occurs between the own object and at least one other object. An optional classification can be used to refine the accuracy of the collision prediction.

The method according to the present invention receives the current status of the own object and the status of the other objects, in real time, from other functions (e.g. a Kalman filter) that execute in the object. From an optional classification function, the method according to the present invention receives the object types – e.g. pedestrian, bicyclist, small motor vehicle, medium motor vehicle, large motor vehicle or truck – in order to determine, using that information and a predefined dynamic vehicle model (one for each specific vehicle class, and optionally as a function of a vehicle behavior model), the collision probability and hazard probability. Each object has a dynamic model of this kind assigned to it, so that the future behavior of the object can be optimally estimated in consideration of current parameters such as speed and acceleration. In addition, a behavior model for the driver or pedestrian can be taken into account here. This model then indicates in each case how probable behaviors are under the given boundary conditions. Incorporation of this model also improves the prediction of the future position of an object or traffic participant.

A Kalman filter can be generated for each observed object. The motion possibilities of the object are embodied in the Kalman filter in model form. The Kalman filter allows optimum

combination of the new observations, which generally contain errors, and the model knowledge.

This information then permits a determination of the accident risk so that an actuator suite can be triggered, if applicable, even before a possible collision. This can result in optimum protection of a vehicle occupant and/or other vehicle occupants such as pedestrians. Control aids for collision avoidance can also be optimally used in this fashion.

Present-day safety systems for vehicles detect collisions after the accident has begun, so that in general there is no possibility for an action that might prevent or mitigate the collision. Such action, could, however, mean valuable time for the vehicle occupants and/or other traffic participants such as pedestrians. The method according to the present invention makes this possible, and also permits the corresponding application of countermeasures. The method according to the present invention permits the application of countermeasures that require more time than those that can be used when a collision has already occurred. For example, a visual or acoustic warning, proceeding from the method according to the present invention for determining an accident risk, can be outputted promptly enough to provide the driver with sufficient time to react in order to avoid the collision. In addition, the method according to the present invention allows a vehicle behavior model to be modified so that in the event of a high accident risk, it can react accordingly. As a result, it is possible for the method according to the present invention to adjust to behavior patterns of individual drivers.

The method according to the present invention makes it possible to store a variety of motion sequences with probabilities, in order then to initiate countermeasures as a function of the hazard probability. Only when the combination of individual states results in a high hazard probability can initiation of a countermeasure be indicated. The method according to the present invention is suitable in particular for two-dimensional cases, i.e. motions, for example, on roads or on water surfaces. It is also possible, however, to apply the method according to the present invention in a three-dimensional space. The method according to the present invention is thus also usable for air traffic and the motion of robots, or for use in underwater traffic.

The features and refinements presented in the dependent claims make possible advantageous improvements to the method described in the independent claim for determining an accident risk of a first object with at least one second object.

It is particularly advantageous that the motion and the object class of the at least one second object are determined by a sensor apparatus, and the motion and object class of the first object are retrieved from at least one data source. This means that the other objects -- for example pedestrians, bicyclists, and other vehicles -- surrounding the first object – for example a vehicle -- are sensed using a sensor suite such as a pre-crash sensor suite, so that they can be classified and have motion parameters assigned to them. The own-vehicle values are retrieved from internal data sources, i.e. the vehicle type, current speed, direction, and a vehicle behavior model. Such sources are thus internal sensors and memories.

It is additionally advantageous that the motion of the first object is defined at least by way of its current position and its velocity. This yields a velocity vector that defines the relationship to the other objects. The motion of the other objects is defined at least by way of their current position. If stationary objects are involved, it is therefore not necessary to determine their velocity; only their position needs to be determined in order to determine the collision and hazard probabilities. For the first object, its longitudinal and/or transverse acceleration and/or its rotation angle or variables derived therefrom and/or its steering angle can additionally be used as further parameters for definition of the motion. Environmental influences, i.e. the road condition or defined maximum speeds, and/or a respective vehicle behavior, can be taken into consideration by the corresponding model in determining the motion.

Lastly, it is also advantageous that as a function of the accident risk, an indication, i.e. a warning to the driver, and/or a message and/or at least one signal to an actuator suite, is generated. A control unit in a vehicle, or a restraint system, can preferably be used in the method according to the present invention. Motor vehicles, ships, aircraft, and robots are possible as objects.

Drawings

Exemplified embodiments of the invention are depicted in the drawings and are explained in more detail in the description below.

Figure 1 is a block diagram of an apparatus according to the present invention;

Figure 2 is a flow chart of the method according to the present invention;

Figure 3 is a block diagram of the method according to the present invention;

Figure 4 is a diagram of the times required by various countermeasures for activation;

Figure 5 shows a first model for determining the hazard probability; and

Figure 6 shows a second model for determining the hazard probability.

Description

Impact sensors are already in common use in motor vehicles. In addition, pre-crash sensors such as radar or ultrasound or video are also increasingly being used to monitor the vehicle surroundings. On the basis of this kind of all-around view, reversible restraint means such as belt tensioners, for example, can be used as a risk approaches. A more accurate analysis of the motion of the objects surrounding the vehicle is necessary, however, in order for suitable countermeasures to be applied in as prompt and situationally appropriate a manner as possible.

The present invention now proposes a method for determining an accident risk that analyzes surroundings data more accurately so that countermeasures can thus be applied in situationally appropriate fashion. In particular, a hazard probability, which also considers the immediate vicinity around an object,

is calculated here in addition to a collision probability. The method according to the present invention is not limited to utilization for road traffic, however; it can also be used for air traffic and shipping, in situations where robots are used, and for other applications.

Figure 1 shows an apparatus according to the present invention as a block diagram. A surroundings sensor suite 1 is connected to a processor 2. Sensor suite 1 transfers measured data to processor 2, which processes them. For that processing, processor 2 is connected via a data input/output to a memory 3. Processor 2 is connected via a first data output to an indicator 4. This indicator 4 serves to warn a driver, and is preferably embodied here as an optical indicator. Alternatively, it is possible for indicator 4, additionally or instead, to have a loudspeaker in order, also or alternatively, to warn the driver acoustically. A haptic warning by way of moving elements, in order to warn the driver by touch, is also conceivable here.

Processor 2 is connected via a second data output to a restraint system 5 that is used to protect the occupants in the event of an impact. Restraint system 5 encompasses restraint means such as a belt tensioner and airbags that are used for various body parts. The belt tensioners can be embodied pyrotechnically and/or reversibly, a reversible belt tensioner usually being operated by an electric motor. In addition to normal front airbags, side airbags, knee bags, and other airbags for special types of accident can be used.

Processor 2 uses data via an interior sensing system upon utilization of these restraint means 5. The result is that if use of the restraint means is possibly hazardous, that use is

suppressed in order to prevent injuries resulting from such restraint means. This applies, for example, when the person in question is located too close to a restraint means (e.g. is "out of position"), or when the person in question weighs so little that the force applied by an airbag might cause injuries. Pressure-based systems such as a seat mat or force sensors, or also wave-based interior sensor suites such as ultrasound, video, or infrared or high-frequency, can be used as the interior sensor suite. Processor 2 is connected via a third data output to an active steering aid 6 in order to assist the driver in avoiding a collision. It is possible for the processor to be connected only to restraint means 5 and/or to indicator 4 and/or to steering aid 6.

Restraint means 5 also include restraint means for the protection of pedestrians or bicyclists. These include raising the hood in order to protect such persons from impact against the engine block or windshield. The absorption characteristics of the bumper can also be appropriately adapted, and the vehicle or vehicle front can be raised or lowered in order to achieve improved crash compatibility. External airbags are also usable here in order to protect pedestrians and other traffic participants, for example in a vehicle/vehicle collision.

Processor 2 then evaluates the sensor signals of sensor suite 1 in order to combine them with a model – the dynamic vehicle model and optionally the driver model – that is loaded from memory 3. Data from data sources in the vehicle, temporarily stored in memory 3, are also needed in order to calculate the collision speed and approach speed. Those data include the own-vehicle type, speed, speed direction, acceleration in the

vehicle, and also rotational acceleration expressed as rotation angles.

Using the collision and hazard probabilities, it is possible for processor 2 to calculate the accident risk for the current scenario as a function of the loaded data. Corresponding countermeasures are initiated as a function of that accident risk. A restraint system, or a system for acting on the vehicle behavior, can therefore then operate in situationally appropriate fashion.

Figure 2 shows, as a first flow chart, the method according to the present invention for determining an accident risk. In method step 7, a characterization of the motion of collision objects in the vehicle's surroundings is performed by sensor suite 1. This characterization is accomplished on the basis of the following parameters: current position, relative speed with respect to the observed object, and the longitudinal and transverse acceleration and rotational acceleration of the respective objects. An optional classification of the individual collision objects is furthermore performed by processor 2. This classification includes the vehicle type. That vehicle type is ascertained by sensor suite 1. Pattern recognition means can preferably be used in order to evaluate the sensor signals (e.g. video, radar, or ultrasound signals) and assign them to vehicle types. The motion parameters of the vehicle to be observed are also ascertained by way of sensor suite 1. As stated above, these include the vehicle position, vehicle speed, accelerations in the longitudinal and transverse directions, and rotational accelerations, all of which are derivable from such all-around view signals. Alternatively, it is possible for a communication to exist

between the vehicles, making possible an exchange of such vehicle data.

In method step 8, the motion and object class are performed by retrieval from a memory, for example memory 3, in the vehicle in which the method according to the present invention is executing. The speed is known by way of the speedometer; longitudinal, transverse, and angular accelerations can be determined by way of internal acceleration sensors; the steering angle can be ascertained by a corresponding sensor. The object class, i.e. the vehicle model, can be stored in a memory. As an alternative to the speedometer, the speed can be determined by way of a satellite-assisted location signal such as GPS; radar sensors can also be used here in combination with inertial sensors.

From these data it is then possible, in method steps 9 and 10, to determine the collision probability and hazard probability. A dynamic model of the vehicle is used here. This dynamic model is dependent on the object class and can thus be loaded, for each vehicle, from memory 3. A driver behavior model can additionally be taken into consideration. This driver behavior model contains at least one model that assigns a probability to an action of the driver. In conjunction with the dynamic model of the vehicle, this enables the method according to the present invention to assign probabilities to all possible future states of the one vehicle and the other objects. A state encompasses at least the position, and optionally also the speed and orientation, as well as accelerations, rotation rates, and rotational accelerations.

In the simplest case only a driver behavior model is used, which is then the same for the own vehicle and the other

objects. This model can be improved for the own vehicle using an adaptive model by using a driver observation sensor, or by observation of the driver's reaction in critical situations.

In method step 11, the accident risk is then estimated by the collision probability and hazard probability that have been determined. As a function of the accident risk, an initiation of countermeasures is then performed in method step 12. These countermeasures include activation of restraint systems, output of warnings to the driver, and driver assistance in avoiding collisions.

Figure 3 shows, in a block diagram, the execution of the method according to the present invention. Sensor suite 1 here has impact sensors 22, sensors for detecting vehicle dynamics 23, surroundings sensors 24, environment sensors 25, and driver observation sensors 26. It is possible to dispense with environment sensors 25 and driver observation sensors 26. Impact sensors 22 supply a signal that is used in block 27 to determine the accident risk and the activation of the actuator suite. Vehicle dynamics sensors 23 are used to track the motion of the own vehicle in block 31. These data then go into block 34, in which the collision probability and hazard probability are determined.

Surroundings sensors 24 supply their data to an object detection system 28. Object detection system 28 introduces the object detection data into a classification module 29 in order to classify the surrounding objects. Those objects are then, in the next block 30, tracked using data from the object classification and object detection systems. These tracking data of block 30 are then also used in block 34 to determine the collision probability and hazard probability, although

vehicle dynamics model 32 and optionally driver behavior model 33 are also taken into account in this context. Data from environment sensors 25 go into vehicle dynamics model 32. These sensors 25 supply data regarding the road, friction, and optionally temperature, as well as other parameters. Vehicle dynamics model 32 is then adapted therewith. Data from driver observation sensor 26 go into driver behavior model 33. This sensor 26 supplies data concerning the driver's attentiveness. Sensors that observe eyelid blinking, for example, can be used for this, although other vigilance sensors are also usable.

The collision and approach probabilities determined in block 34 are conveyed to module 27 in order to determine the accident risk. Data are also conveyed from block 27 to driver behavior model 33, however, in order to adapt the driver behavior model as a function of the driver's actions. Model 27 then performs an activation of actuator suite 35 as a function of the accident risk. This includes a restraint system 36; a collision avoidance system 37, e.g. by way of an automatic steering intervention or automatic braking action; a crash mitigation system 38, for example an adaptation of the bumper, raising/lowering of the vehicle front, vehicle/vehicle airbags, or collapsible front wheels in order encourage the colliding vehicles to slide apart; a pedestrian protection apparatus 39, for example a raising of the hood or pedestrian airbags; and a driver warning 40, which can be implemented by way of indicator 4 or a loudspeaker. A haptic output is possible here as well.

Figure 4 is a diagram showing the times required for activation of various countermeasures and, by way of example, the calculated probabilities of the time to collision.

The collision probability and hazard probability are plotted on the ordinate 41; each can assume a maximum value of 1. The value 1 means that the collision or hazard will definitely occur within the predicted time.

The time before the collision needed to initiate a countermeasure is depicted on abscissa 42. This time requirement is described qualitatively in 43. Certain actions can be initiated even after the collision; other actions require milliseconds to seconds before the collision. Below the time axis, a variety of countermeasures are arranged on the time axis in accordance with their respective time requirements. The double arrows qualitatively show time spans for the beginning of activation. When that time span has elapsed, the countermeasure should no longer be activated.

Curve 44 shows, as a typical example, the collision probability rising with decreasing time until the collision, and curve 45 shows the similarly rising hazard probability. These profiles are typical of cases in which a collision later actually occurs.

The hazard probability is in principle greater than or equal to the collision probability, since the hazard, which means an excessively close pass, includes the instance of a collision.

Behind curves 44 and 45, and cross-hatched in each case, is the unavoidable uncertainty regarding the result for the collision and hazard probabilities. This uncertainty is caused, for example, by measurement errors. It tends to decrease as time proceeds, since the number of observations rises and the measurement errors likewise become small for a smaller object distance.

The earlier the countermeasure must be initiated, the greater the remaining probability at that point in time that the collision will not occur, i.e. that the countermeasure is initiated unnecessarily. This may result, for example, from the fact that an escape opportunity still exists that an experienced driver might perceive.

Countermeasures that require a long activation time should consequently, if possible, cause no damage or only minor damage if improperly triggered.

The calculated values for the collision probability and hazard probability can be compared with thresholds. If the probability under consideration exceeds the threshold during the time period characterized by a double arrow, the corresponding countermeasure can then be activated. Activation also takes place if the threshold has already been exceeded as that time period is entered. The point in time for enabling activation is defined by the first intersection point 47 of curve 44 or 45 with curve 46. Threshold 46 need not necessarily be constant; thresholds that change over time are also usable.

Example: For the "Warn driver" countermeasure, curve 46 depicting the threshold for activation of a warning is drawn in by way of example. (Additional thresholds have been omitted for reasons of clarity.) If the hazard probability exceeds that threshold during the time period characterized by the double arrow, a warning is then outputted. Once that time period has elapsed, there is no further need to output a warning, since the driver no longer has sufficient time for a reaction.

For countermeasures such as, for example, warning the driver, which in turn cause no damage in normal circumstances, the hazard probability can be utilized for comparison with the threshold in order to provide a warning even before the threat of a near miss. For other countermeasures, the collision probability is preferable. There is no difference in principle between the two probabilities; the collision probability merely represents a special case of the hazard probability.

Close to the origin of the diagram, the time needed in order to initiate a countermeasure is very short. Ultimately, the only action here is to modify the airbag triggering algorithm. If the time for initiation of countermeasures is somewhat greater, the pyrotechnic belt tensioner can then also still be used. If even more time is available, the reversible belt tensioner can also be used. With even more time, measures can be taken to enhance vehicle compatibility for a crash. As the next stage, it is possible to activate automatic braking. If even more time is available, automatic steering can also be taken into consideration. As the lowest action, the driver's reaction can be observed and he/she can be given acoustic or optical instructions as applicable.

Figure 5 shows schematically, from a bird's-eye perspective, how the collision probability can be determined. Own object 48 is here convoluted with second object 49, so that region 50 is created in the coordinate system of the own object. This involves placing the own object with its reference point "+" at the origin, and disposing second object 49 in multiple fashion around own object 48 in such a way that contact just occurs between objects 48 and 49. In multiple assemblage 51, reference point "x" of the second object describes a contour that represents the outline (edge) of region 50. This is the

region that is taken into consideration for the collision probability. This region must be checked as to whether, at a future point in time, reference point "x" of the second object will be located within it. If so, this corresponds to a collision. If such is not the case, then a collision does not exist.

Figure 5 represents a simplified and therefore less accurate variant for determining the region, since the objects here are assumed to be circular, which in turn results in a circular region as the convolution result. This simplification was dispensed with in Figure 6. Two oriented objects are depicted: own object 52 and second object 53. The convolution then results in region 55 depicted on the right side. Own object 52 is surrounded by other object 54, once again in contact, the orientation here being taken into consideration. Reference point "x" of the second object again describes the outline (edge) of region 55.

In order to determine the region that is taken into account for the hazard probability, the procedure is at first exactly the same as depicted in Figures 5 and 6. In addition, region 50 or 55 is also convoluted with a further region disposed in circular fashion around the origin. The radius of this circle is to be interpreted as the minimum safe distance between the objects. The sequence of the two convolutions is arbitrary, i.e. without changing the final result, it is possible instead to convolute one of the objects with the circular region and then to convolute the intermediate result with the other object.

The probabilities are determined by calculating probability density functions and integrating them, a determination being

made on the basis of region 50 or 55, for each combination of the residence locations of the two objects (a residence location being determined in each case by the position of the object's reference point), as to whether or not a collision or hazard exists.

A quantization is used for the residence locations, the sampling being dense for short prediction times and more widely spaced for longer prediction times.

The non-action course is the course taken by the vehicle if no action is taken by the driver in order to modify the vehicle parameters, i.e. the speed and the acceleration vector. That course therefore continues to be followed if no changes are made by the driver in terms of steering or braking or acceleration. This typically occurs when the driver has not yet recognized the threatening situation or has assessed it incorrectly. The collision probability of the non-action course that is prepared by the driver behavior model is generally much greater than the probabilities of other possible courses. It is therefore advisable to model this non-action course separately, specifically with a greater precision, so that the remaining probability can then be distributed among all the other courses that the driver can take. These other courses are caused by braking, steering, or acceleration. The method according to the present invention for determining the accident risk, in which the collision probability and hazard probability are determined, depend on three parameters:

1) The initial states, made available by way of real-time sensor information, of the first and the further objects.

2) A vehicle dynamics model is used to predict future positions of the own vehicle and the other objects, taking into account the real-time sensor information.

3) A driver behavior model is used to assign probabilities of possible future positions of the own vehicle and the other objects.

The quality of the method according to the present invention can be enhanced by improving these input parameters. For example, using the object class as an input parameter increases the accuracy of the collision and hazard probabilities. This is because physical boundaries of the individual objects reduce the number of possible future positions of the respective object.

Instead of considering vehicle dynamics models, it is also possible to select general dynamics models that incorporate pedestrians as well. This also applies to the concept of the driver behavior model, which can be expanded to a general behavior model and also takes pedestrians into consideration.

What Is Claimed Is:

1. A method for determining an accident risk of a first object (48, 52) with at least one second object (49; 53), the accident risk being determined as a function of a collision probability and a hazard probability of the at least one second object (49, 53) in a predefined region (50, 55), the collision probability and the hazard probability being determined as a function of motions of the first and at least one second object.

2. The method as recited in Claim 1, wherein an object class of the first and at least one second object are taken into account in determining the collision probability and the hazard probability.

3. The method as recited in Claim 1 and 2, wherein the motion and the object class of the at least one second object are determined by way of a sensor suite (1), and the motion and the object class of the first object (48, 52) are retrieved from at least one data source.

4. The method as recited in Claim 1 or 2, wherein the motion of the first object (48, 52) is defined by way of at least one current position and its velocity.

5. The method as recited in one of the preceding claims, wherein the motion of the at least one second object (49, 53) is defined by way of at least one current position.

6. The method as recited in Claim 4, wherein the motion of the first object is additionally determined by way of its first longitudinal and/or transverse

acceleration and/or a first rotation angle and/or a steering angle.

7. The method as recited in Claim 5, wherein the motion of the at least one second object is additionally determined by way of its velocity relative to the first object and/or a second longitudinal acceleration and/or a second transverse acceleration and/or a second rotation angle.

8. The method as recited in Claim 6 or 7, wherein environmental influences and/or a respective driving behavior are taken into account in determining the respective motion.

9. The method as recited in one of the preceding claims, wherein an indication (4) and/or at least one signal to an actuator suite (35) are generated as a function of the accident risk.

10. Use of a control unit in a vehicle constituting an object in a method as recited in one of Claims 1 through 9.

11. Use of a restraint system (5) in a vehicle constituting an object in a method as recited in one of Claims 1 through 9.

Abstract

A method for determining an accident risk of a first object with at least one second object is proposed, a collision probability and a hazard probability of the at least one second object being determined in a predefined region around the first object, the collision probability and the hazard probability being determined as a function of motions and object classes of the first and the at least one second object. The accident risk is then determined as a function of the collision probability and the hazard probability.

(Figure 3)

Fig. 1

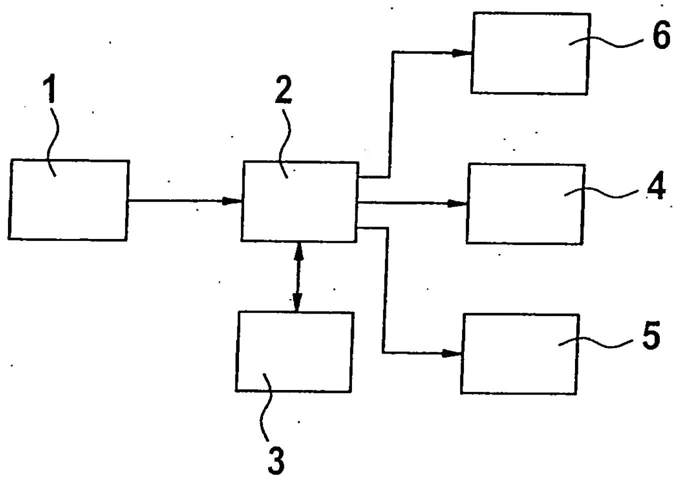


Fig. 2

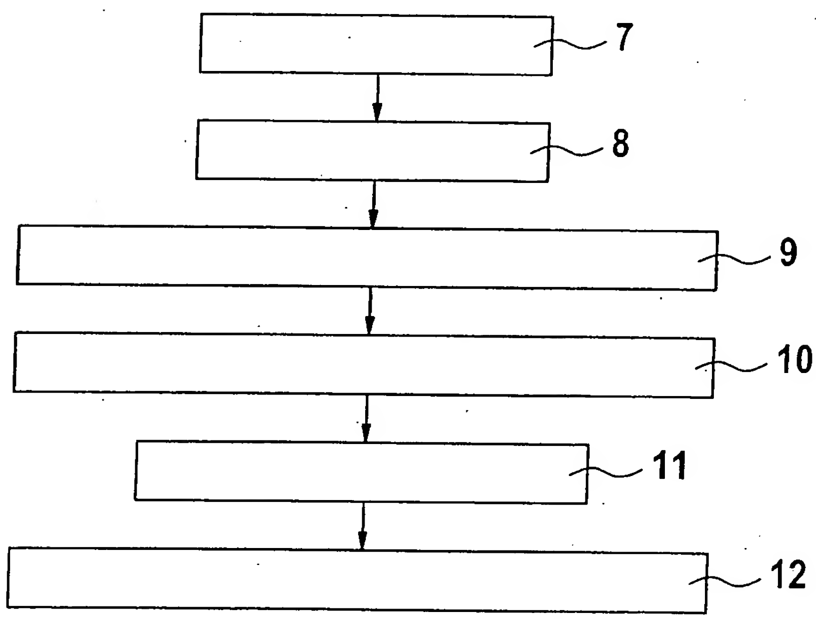


Fig. 3

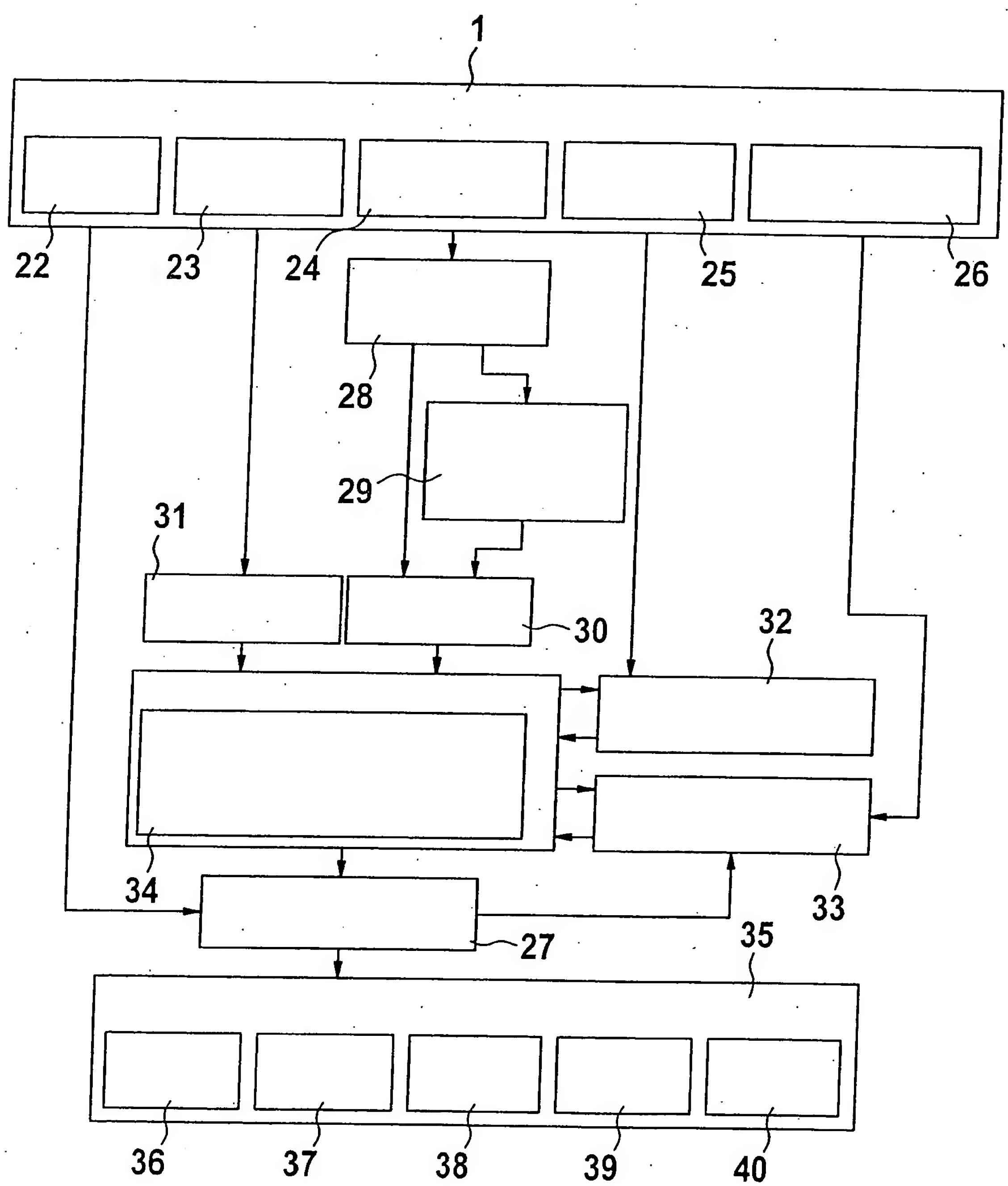


Fig. 4

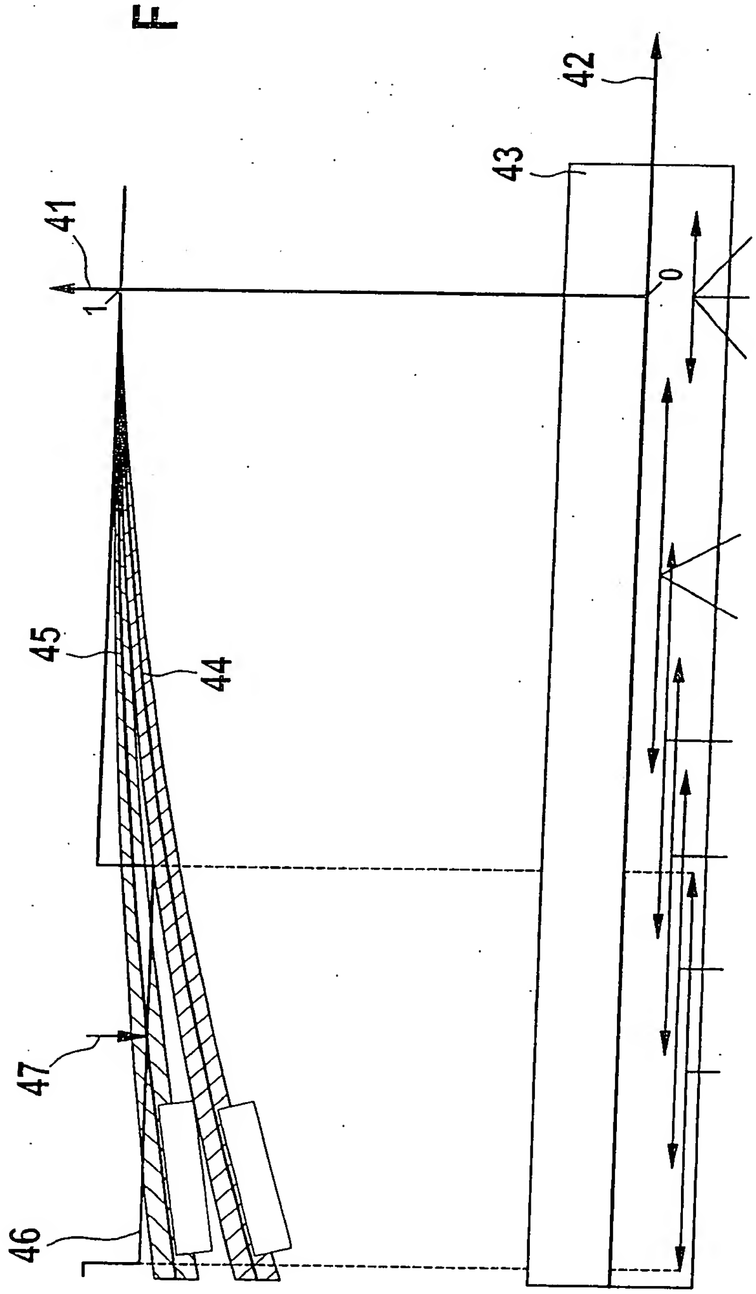


Fig. 5

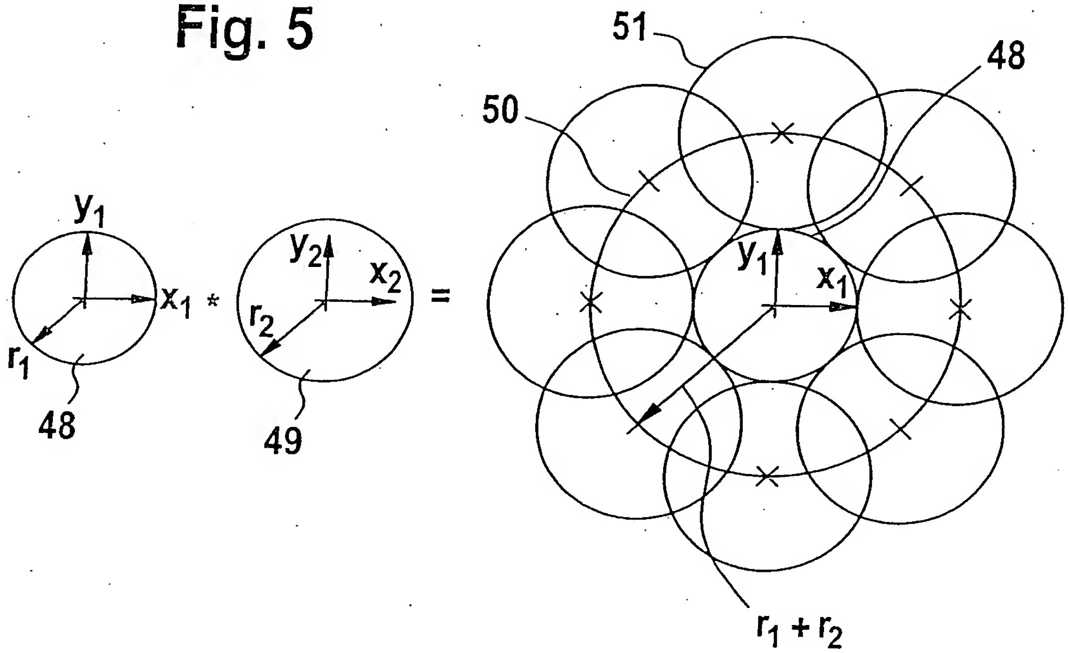
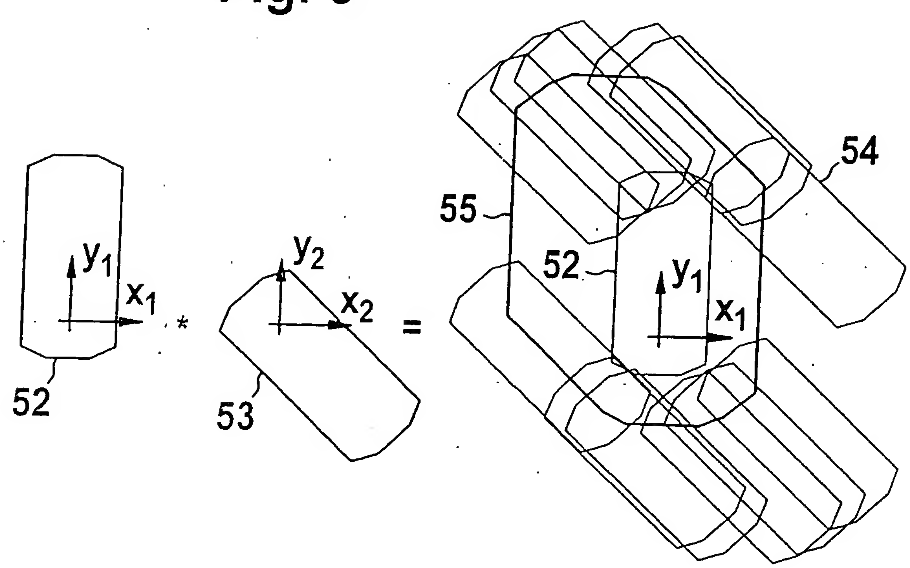

y1
x1
r1
48
*
y2
x2
r2
49
=
51
48
50
y1
x1
r1 + r2

Fig. 6


y1
x1
52
*
y2
x2
53
=
54
55
52
y1
x1

[10191/3675]

METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional application 60/378,444, which is hereby incorporated by reference and which was filed on May 7, 2002.

Background Information

The present invention ~~proceeds from~~is directed to a method for determining an accident risk of a first object with at least one second object~~, according to the species defined in the independent claim~~.

~~Advantages~~Summary of the Invention

The method according to the present invention for determining an accident risk of a first object with at least one second object~~, having the features of the independent claim,~~ has the advantage that the collision probability of an own vehicle with one or more other objects can be determined. These collision probabilities can be evaluated, for example, by a control unit for restraint systems or other safety systems and used, even before the collision occurs, to initiate actions that mitigate the effects of the collision or in fact prevent it.

The method according to the present invention requires the detection of objects, and determines the status of the own object and of the other objects in the vicinity, the collision probability and a hazard probability between the own object and the other objects being determined. An accident risk is

then derived therefrom. The "hazard probability" is understood here as a probability of at least a near miss; this means that a region is drawn around the own object, and the probability that other objects might enter that region around the own object is calculated. The collision itself is thus also detected from the hazard probability. The "collision probability," on the other hand, means that an overlap or crash occurs between the own object and at least one other object. An optional classification can be used to refine the accuracy of the collision prediction.

The method according to the present invention receives the current status of the own object and the status of the other objects, in real time, from other functions (e.g. a Kalman filter) that execute in the object. From an optional classification function, the method according to the present invention receives the object types – e.g. pedestrian, bicyclist, small motor vehicle, medium motor vehicle, large motor vehicle or truck – in order to determine, using that information and a predefined dynamic vehicle model (one for each specific vehicle class, and optionally as a function of a vehicle behavior model), the collision probability and hazard probability. Each object has a dynamic model of this kind assigned to it, so that the future behavior of the object can be optimally estimated in consideration of current parameters such as speed and acceleration. In addition, a behavior model for the driver or pedestrian can be taken into account here. This model then indicates in each case how probable behaviors are under the given boundary conditions. Incorporation of this model also improves the prediction of the future position of an object or traffic participant.

A Kalman filter can be generated for each observed object. The motion possibilities of the object are embodied in the Kalman filter in model form. The Kalman filter allows optimum combination of the new observations, which generally contain errors, and the model knowledge.

This information then permits a determination of the accident risk so that an actuator suite can be triggered, if applicable, even before a possible collision. This can result in optimum protection of a vehicle occupant and/or other vehicle occupants such as pedestrians. Control aids for collision avoidance can also be optimally used in this fashion.

Present-day safety systems for vehicles detect collisions after the accident has begun, so that in general there is no possibility for an action that might prevent or mitigate the collision. Such action, could, however, mean valuable time for the vehicle occupants and/or other traffic participants such as pedestrians. The method according to the present invention makes this possible, and also permits the corresponding application of countermeasures. The method according to the present invention permits the application of countermeasures that require more time than those that can be used when a collision has already occurred. For example, a visual or acoustic warning, proceeding from the method according to the present invention for determining an accident risk, can be outputted promptly enough to provide the driver with sufficient time to react in order to avoid the collision. In addition, the method according to the present invention allows a vehicle behavior model to be modified so that in the event of a high accident risk, it can react accordingly. As a result, it is possible for the method according to the present

invention to adjust to behavior patterns of individual drivers.

The method according to the present invention makes it possible to store a variety of motion sequences with probabilities, in order then to initiate countermeasures as a function of the hazard probability. Only when the combination of individual states results in a high hazard probability can initiation of a countermeasure be indicated. The method according to the present invention is suitable in particular for two-dimensional cases, i.e. motions, for example, on roads or on water surfaces. It is also possible, however, to apply the method according to the present invention in a three-dimensional space. The method according to the present invention is thus also usable for air traffic and the motion of robots, or for use in underwater traffic.

Brief Description of the Drawings

Exemplified embodiments of the invention are depicted in the drawings and are explained in more detail in the description below.

Figure 1 is a block diagram of an apparatus according to the present invention;

Figure 2 is a flow chart of the method according to the present invention;

Figure 3 is a block diagram of the method according to the present invention;

Figure 4 is a diagram of the times required by various countermeasures for activation;

Figure 5 shows a first model for determining the hazard probability; and

Figure 6 shows a second model for determining the hazard probability.

~~The features and refinements presented in the dependent claims make possible advantageous improvements to the method described in the independent claim for determining an accident risk of a first object with at least one second object.~~

Detailed Description of the Invention

It is particularly advantageous that the motion and the object class of the at least one second object are determined by a sensor apparatus, and the motion and object class of the first object are retrieved from at least one data source. This means that the other objects -- for example pedestrians, bicyclists, and other vehicles -- surrounding the first object – for example a vehicle -- are sensed using a sensor suite such as a pre-crash sensor suite, so that they can be classified and have motion parameters assigned to them. The own-vehicle values are retrieved from internal data sources, i.e. the vehicle type, current speed, direction, and a vehicle behavior model. Such sources are thus internal sensors and memories.

It is additionally advantageous that the motion of the first object is defined at least by way of its current position and its velocity. This yields a velocity vector that defines the relationship to the other objects. The motion of the other objects is defined at least by way of their current position. If stationary objects are involved, it is therefore not

necessary to determine their velocity; only their position needs to be determined in order to determine the collision and hazard probabilities. For the first object, its longitudinal and/or transverse acceleration and/or its rotation angle or variables derived therefrom and/or its steering angle can additionally be used as further parameters for definition of the motion. Environmental influences, i.e. the road condition or defined maximum speeds, and/or a respective vehicle behavior, can be taken into consideration by the corresponding model in determining the motion.

Lastly, it is also advantageous that as a function of the accident risk, an indication, i.e. a warning to the driver, and/or a message and/or at least one signal to an actuator suite, is generated. A control unit in a vehicle, or a restraint system, can preferably be used in the method according to the present invention. Motor vehicles, ships, aircraft, and robots are possible as objects.

~~Drawings~~

~~Exemplified embodiments of the invention are depicted in the drawings and are explained in more detail in the description below.~~

~~Figure 1 is a block diagram of an apparatus according to the present invention;~~

~~Figure 2 is a flow chart of the method according to the present invention;~~

~~Figure 3 is a block diagram of the method according to the present invention;~~

~~Figure 4 is a diagram of the times required by various countermeasures for activation;~~

~~Figure 5 shows a first model for determining the hazard probability; and~~

~~Figure 6 shows a second model for determining the hazard probability.~~

~~Description~~

Impact sensors are already in common use in motor vehicles. In addition, pre-crash sensors such as radar or ultrasound or video are also increasingly being used to monitor the vehicle surroundings. On the basis of this kind of all-around view, reversible restraint means such as belt tensioners, for example, can be used as a risk approaches. A more accurate analysis of the motion of the objects surrounding the vehicle is necessary, however, in order for suitable countermeasures to be applied in as prompt and situationally appropriate a manner as possible.

The present invention now proposes a method for determining an accident risk that analyzes surroundings data more accurately so that countermeasures can thus be applied in situationally appropriate fashion. In particular, a hazard probability, which also considers the immediate vicinity around an object, is calculated here in addition to a collision probability. The method according to the present invention is not limited to utilization for road traffic, however; it can also be used for air traffic and shipping, in situations where robots are used, and for other applications.

Figure 1 shows an apparatus according to the present invention as a block diagram. A surroundings sensor suite 1 is connected to a processor 2. Sensor suite 1 transfers measured data to processor 2, which processes them. For that processing, processor 2 is connected via a data input/output to a memory 3. Processor 2 is connected via a first data output to an

indicator 4. This indicator 4 serves to warn a driver, and is preferably embodied here as an optical indicator. Alternatively, it is possible for indicator 4, additionally or instead, to have a loudspeaker in order, also or alternatively, to warn the driver acoustically. A haptic warning by way of moving elements, in order to warn the driver by touch, is also conceivable here.

Processor 2 is connected via a second data output to a restraint system 5 that is used to protect the occupants in the event of an impact. Restraint system 5 encompasses restraint means such as a belt tensioner and airbags that are used for various body parts. The belt tensioners can be embodied pyrotechnically and/or reversibly, a reversible belt tensioner usually being operated by an electric motor. In addition to normal front airbags, side airbags, knee bags, and other airbags for special types of accident can be used.

Processor 2 uses data via an interior sensing system upon utilization of these restraint means 5. The result is that if use of the restraint means is possibly hazardous, that use is suppressed in order to prevent injuries resulting from such restraint means. This applies, for example, when the person in question is located too close to a restraint means (e.g. is "out of position"), or when the person in question weighs so little that the force applied by an airbag might cause injuries. Pressure-based systems such as a seat mat or force sensors, or also wave-based interior sensor suites such as ultrasound, video, or infrared or high-frequency, can be used as the interior sensor suite. Processor 2 is connected via a third data output to an active steering aid 6 in order to assist the driver in avoiding a collision. It is possible for the processor to be connected only to restraint means 5 and/or to indicator 4 and/or to steering aid 6.

Restraint means 5 also include restraint means for the protection of pedestrians or bicyclists. These include raising

the hood in order to protect such persons from impact against the engine block or windshield. The absorption characteristics of the bumper can also be appropriately adapted, and the vehicle or vehicle front can be raised or lowered in order to achieve improved crash compatibility. External airbags are also usable here in order to protect pedestrians and other traffic participants, for example in a vehicle/vehicle collision.

Processor 2 then evaluates the sensor signals of sensor suite 1 in order to combine them with a model — the dynamic vehicle model and optionally the driver model — that is loaded from memory 3. Data from data sources in the vehicle, temporarily stored in memory 3, are also needed in order to calculate the collision speed and approach speed. Those data include the own-vehicle type, speed, speed direction, acceleration in the vehicle, and also rotational acceleration expressed as rotation angles.

Using the collision and hazard probabilities, it is possible for processor 2 to calculate the accident risk for the current scenario as a function of the loaded data. Corresponding countermeasures are initiated as a function of that accident risk. A restraint system, or a system for acting on the vehicle behavior, can therefore then operate in situationally appropriate fashion.

Figure 2 shows, as a first flow chart, the method according to the present invention for determining an accident risk. In method step 7, a characterization of the motion of collision objects in the vehicle's surroundings is performed by sensor suite 1. This characterization is accomplished on the basis of the following parameters: current position, relative speed with respect to the observed object, and the longitudinal and transverse acceleration and rotational acceleration of the respective objects. An optional classification of the individual collision objects is furthermore performed by

processor 2. This classification includes the vehicle type. That vehicle type is ascertained by sensor suite 1. Pattern recognition means can preferably be used in order to evaluate the sensor signals (e.g. video, radar, or ultrasound signals) and assign them to vehicle types. The motion parameters of the vehicle to be observed are also ascertained by way of sensor suite 1. As stated above, these include the vehicle position, vehicle speed, accelerations in the longitudinal and transverse directions, and rotational accelerations, all of which are derivable from such all-around view signals. Alternatively, it is possible for a communication to exist between the vehicles, making possible an exchange of such vehicle data.

In method step 8, the motion and object class are performed by retrieval from a memory, for example memory 3, in the vehicle in which the method according to the present invention is executing. The speed is known by way of the speedometer; longitudinal, transverse, and angular accelerations can be determined by way of internal acceleration sensors; the steering angle can be ascertained by a corresponding sensor. The object class, i.e. the vehicle model, can be stored in a memory. As an alternative to the speedometer, the speed can be determined by way of a satellite-assisted location signal such as GPS; radar sensors can also be used here in combination with inertial sensors.

From these data it is then possible, in method steps 9 and 10, to determine the collision probability and hazard probability. A dynamic model of the vehicle is used here. This dynamic model is dependent on the object class and can thus be loaded, for each vehicle, from memory 3. A driver behavior model can additionally be taken into consideration. This driver behavior model contains at least one model that assigns a probability to an action of the driver. In conjunction with the dynamic model of the vehicle, this enables the method according to the present invention to assign probabilities to all possible

future states of the one vehicle and the other objects. A state encompasses at least the position, and optionally also the speed and orientation, as well as accelerations, rotation rates, and rotational accelerations.

In the simplest case only a driver behavior model is used, which is then the same for the own vehicle and the other objects. This model can be improved for the own vehicle using an adaptive model by using a driver observation sensor, or by observation of the driver's reaction in critical situations.

In method step 11, the accident risk is then estimated by the collision probability and hazard probability that have been determined. As a function of the accident risk, an initiation of countermeasures is then performed in method step 12. These countermeasures include activation of restraint systems, output of warnings to the driver, and driver assistance in avoiding collisions.

Figure 3 shows, in a block diagram, the execution of the method according to the present invention. Sensor suite 1 here has impact sensors 22, sensors for detecting vehicle dynamics 23, surroundings sensors 24, environment sensors 25, and driver observation sensors 26. It is possible to dispense with environment sensors 25 and driver observation sensors 26. Impact sensors 22 supply a signal that is used in block 27 to determine the accident risk and the activation of the actuator suite. Vehicle dynamics sensors 23 are used to track the motion of the own vehicle in block 31. These data then go into block 34, in which the collision probability and hazard probability are determined.

Surroundings sensors 24 supply their data to an object detection system 28. Object detection system 28 introduces the object detection data into a classification module 29 in order to classify the surrounding objects. Those objects are then, in the next block 30, tracked using data from the object

classification and object detection systems. These tracking data of block 30 are then also used in block 34 to determine the collision probability and hazard probability, although vehicle dynamics model 32 and optionally driver behavior model 33 are also taken into account in this context. Data from environment sensors 25 go into vehicle dynamics model 32. These sensors 25 supply data regarding the road, friction, and optionally temperature, as well as other parameters. Vehicle dynamics model 32 is then adapted therewith. Data from driver observation sensor 26 go into driver behavior model 33. This sensor 26 supplies data concerning the driver's attentiveness. Sensors that observe eyelid blinking, for example, can be used for this, although other vigilance sensors are also usable.

The collision and approach probabilities determined in block 34 are conveyed to module 27 in order to determine the accident risk. Data are also conveyed from block 27 to driver behavior model 33, however, in order to adapt the driver behavior model as a function of the driver's actions. Model 27 then performs an activation of actuator suite 35 as a function of the accident risk. This includes a restraint system 36; a collision avoidance system 37, e.g. by way of an automatic steering intervention or automatic braking action; a crash mitigation system 38, for example an adaptation of the bumper, raising/lowering of the vehicle front, vehicle/vehicle airbags, or collapsible front wheels in order encourage the colliding vehicles to slide apart; a pedestrian protection apparatus 39, for example a raising of the hood or pedestrian airbags; and a driver warning 40, which can be implemented by way of indicator 4 or a loudspeaker. A haptic output is possible here as well.

Figure 4 is a diagram showing the times required for activation of various countermeasures and, by way of example, the calculated probabilities of the time to collision. The collision probability and hazard probability are plotted on the ordinate 41; each can assume a maximum value of 1. The

value 1 means that the collision or hazard will definitely occur within the predicted time.

The time before the collision needed to initiate a countermeasure is depicted on abscissa 42. This time requirement is described qualitatively in 43. Certain actions can be initiated even after the collision; other actions require milliseconds to seconds before the collision. Below the time axis, a variety of countermeasures are arranged on the time axis in accordance with their respective time requirements. The double arrows qualitatively show time spans for the beginning of activation. When that time span has elapsed, the countermeasure should no longer be activated.

Curve 44 shows, as a typical example, the collision probability rising with decreasing time until the collision, and curve 45 shows the similarly rising hazard probability. These profiles are typical of cases in which a collision later actually occurs.

The hazard probability is in principle greater than or equal to the collision probability, since the hazard, which means an excessively close pass, includes the instance of a collision.

Behind curves 44 and 45, and cross-hatched in each case, is the unavoidable uncertainty regarding the result for the collision and hazard probabilities. This uncertainty is caused, for example, by measurement errors. It tends to decrease as time proceeds, since the number of observations rises and the measurement errors likewise become small for a smaller object distance.

The earlier the countermeasure must be initiated, the greater the remaining probability at that point in time that the collision will not occur, i.e. that the countermeasure is initiated unnecessarily. This may result, for example, from

the fact that an escape opportunity still exists that an experienced driver might perceive.

Countermeasures that require a long activation time should consequently, if possible, cause no damage or only minor damage if improperly triggered.

The calculated values for the collision probability and hazard probability can be compared with thresholds. If the probability under consideration exceeds the threshold during the time period characterized by a double arrow, the corresponding countermeasure can then be activated. Activation also takes place if the threshold has already been exceeded as that time period is entered. The point in time for enabling activation is defined by the first intersection point 47 of curve 44 or 45 with curve 46. Threshold 46 need not necessarily be constant; thresholds that change over time are also usable.

Example: For the "Warn driver" countermeasure, curve 46 depicting the threshold for activation of a warning is drawn in by way of example. (Additional thresholds have been omitted for reasons of clarity.) If the hazard probability exceeds that threshold during the time period characterized by the double arrow, a warning is then outputted. Once that time period has elapsed, there is no further need to output a warning, since the driver no longer has sufficient time for a reaction.

For countermeasures such as, for example, warning the driver, which in turn cause no damage in normal circumstances, the hazard probability can be utilized for comparison with the threshold in order to provide a warning even before the threat of a near miss. For other countermeasures, the collision probability is preferable. There is no difference in principle between the two probabilities; the collision probability merely represents a special case of the hazard probability.

Close to the origin of the diagram, the time needed in order to initiate a countermeasure is very short. Ultimately, the only action here is to modify the airbag triggering algorithm. If the time for initiation of countermeasures is somewhat greater, the pyrotechnic belt tensioner can then also still be used. If even more time is available, the reversible belt tensioner can also be used. With even more time, measures can be taken to enhance vehicle compatibility for a crash. As the next stage, it is possible to activate automatic braking. If even more time is available, automatic steering can also be taken into consideration. As the lowest action, the driver's reaction can be observed and he/she can be given acoustic or optical instructions as applicable.

Figure 5 shows schematically, from a bird's-eye perspective, how the collision probability can be determined. Own object 48 is here convoluted with second object 49, so that region 50 is created in the coordinate system of the own object. This involves placing the own object with its reference point "+" at the origin, and disposing second object 49 in multiple fashion around own object 48 in such a way that contact just occurs between objects 48 and 49. In multiple assemblage 51, reference point "x" of the second object describes a contour that represents the outline (edge) of region 50. This is the region that is taken into consideration for the collision probability. This region must be checked as to whether, at a future point in time, reference point "x" of the second object will be located within it. If so, this corresponds to a collision. If such is not the case, then a collision does not exist.

Figure 5 represents a simplified and therefore less accurate variant for determining the region, since the objects here are assumed to be circular, which in turn results in a circular region as the convolution result. This simplification was dispensed with in Figure 6. Two oriented objects are depicted:

own object 52 and second object 53. The convolution then results in region 55 depicted on the right side. Own object 52 is surrounded by other object 54, once again in contact, the orientation here being taken into consideration. Reference point "x" of the second object again describes the outline (edge) of region 55.

In order to determine the region that is taken into account for the hazard probability, the procedure is at first exactly the same as depicted in Figures 5 and 6. In addition, region 50 or 55 is also convoluted with a further region disposed in circular fashion around the origin. The radius of this circle is to be interpreted as the minimum safe distance between the objects. The sequence of the two convolutions is arbitrary, i.e. without changing the final result, it is possible instead to convolute one of the objects with the circular region and then to convolute the intermediate result with the other object.

The probabilities are determined by calculating probability density functions and integrating them, a determination being made on the basis of region 50 or 55, for each combination of the residence locations of the two objects (a residence location being determined in each case by the position of the object's reference point), as to whether or not a collision or hazard exists.

A quantization is used for the residence locations, the sampling being dense for short prediction times and more widely spaced for longer prediction times.

The non-action course is the course taken by the vehicle if no action is taken by the driver in order to modify the vehicle parameters, i.e. the speed and the acceleration vector. That course therefore continues to be followed if no changes are made by the driver in terms of steering or braking or acceleration. This typically occurs when the driver has not

yet recognized the threatening situation or has assessed it incorrectly. The collision probability of the non-action course that is prepared by the driver behavior model is generally much greater than the probabilities of other possible courses. It is therefore advisable to model this non-action course separately, specifically with a greater precision, so that the remaining probability can then be distributed among all the other courses that the driver can take. These other courses are caused by braking, steering, or acceleration. The method according to the present invention for determining the accident risk, in which the collision probability and hazard probability are determined, depend on three parameters:

1) The initial states, made available by way of real-time sensor information, of the first and the further objects.

2) A vehicle dynamics model is used to predict future positions of the own vehicle and the other objects, taking into account the real-time sensor information.

3) A driver behavior model is used to assign probabilities of possible future positions of the own vehicle and the other objects.

The quality of the method according to the present invention can be enhanced by improving these input parameters. For example, using the object class as an input parameter increases the accuracy of the collision and hazard probabilities. This is because physical boundaries of the individual objects reduce the number of possible future positions of the respective object.

Instead of considering vehicle dynamics models, it is also possible to select general dynamics models that incorporate pedestrians as well. This also applies to the concept of the

driver behavior model, which can be expanded to a general behavior model and also takes pedestrians into consideration.

~~Abstract~~ ABSTRACT

A method for determining an accident risk of a first object with at least one second object is proposed, a collision probability and a hazard probability of the at least one second object being determined in a predefined region around the first object, the collision probability and the hazard probability being determined as a function of motions and object classes of the first and the at least one second object. The accident risk is then determined as a function of the collision probability and the hazard probability.

~~(Figure 3)~~

METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional application 60/378,444, which is hereby incorporated by reference and which was filed on May 7, 2002.

Background Information

The present invention is directed to a method for determining an accident risk of a first object with at least one second object.

Summary of the Invention

The method according to the present invention for determining an accident risk of a first object with at least one second object has the advantage that the collision probability of an own vehicle with one or more other objects can be determined. These collision probabilities can be evaluated, for example, by a control unit for restraint systems or other safety systems and used, even before the collision occurs, to initiate actions that mitigate the effects of the collision or in fact prevent it.

The method according to the present invention requires the detection of objects, and determines the status of the own object and of the other objects in the vicinity, the collision probability and a hazard probability between the own object and the other objects being determined. An accident risk is

then derived therefrom. The "hazard probability" is understood here as a probability of at least a near miss; this means that a region is drawn around the own object, and the probability that other objects might enter that region around the own object is calculated. The collision itself is thus also detected from the hazard probability. The "collision probability," on the other hand, means that an overlap or crash occurs between the own object and at least one other object. An optional classification can be used to refine the accuracy of the collision prediction.

The method according to the present invention receives the current status of the own object and the status of the other objects, in real time, from other functions (e.g. a Kalman filter) that execute in the object. From an optional classification function, the method according to the present invention receives the object types – e.g. pedestrian, bicyclist, small motor vehicle, medium motor vehicle, large motor vehicle or truck – in order to determine, using that information and a predefined dynamic vehicle model (one for each specific vehicle class, and optionally as a function of a vehicle behavior model), the collision probability and hazard probability. Each object has a dynamic model of this kind assigned to it, so that the future behavior of the object can be optimally estimated in consideration of current parameters such as speed and acceleration. In addition, a behavior model for the driver or pedestrian can be taken into account here. This model then indicates in each case how probable behaviors are under the given boundary conditions. Incorporation of this model also improves the prediction of the future position of an object or traffic participant.

A Kalman filter can be generated for each observed object. The motion possibilities of the object are embodied in the Kalman filter in model form. The Kalman filter allows optimum combination of the new observations, which generally contain errors, and the model knowledge.

This information then permits a determination of the accident risk so that an actuator suite can be triggered, if applicable, even before a possible collision. This can result in optimum protection of a vehicle occupant and/or other vehicle occupants such as pedestrians. Control aids for collision avoidance can also be optimally used in this fashion.

Present-day safety systems for vehicles detect collisions after the accident has begun, so that in general there is no possibility for an action that might prevent or mitigate the collision. Such action, could, however, mean valuable time for the vehicle occupants and/or other traffic participants such as pedestrians. The method according to the present invention makes this possible, and also permits the corresponding application of countermeasures. The method according to the present invention permits the application of countermeasures that require more time than those that can be used when a collision has already occurred. For example, a visual or acoustic warning, proceeding from the method according to the present invention for determining an accident risk, can be outputted promptly enough to provide the driver with sufficient time to react in order to avoid the collision. In addition, the method according to the present invention allows a vehicle behavior model to be modified so that in the event of a high accident risk, it can react accordingly. As a result, it is possible for the method according to the present

invention to adjust to behavior patterns of individual drivers.

The method according to the present invention makes it possible to store a variety of motion sequences with probabilities, in order then to initiate countermeasures as a function of the hazard probability. Only when the combination of individual states results in a high hazard probability can initiation of a countermeasure be indicated. The method according to the present invention is suitable in particular for two-dimensional cases, i.e. motions, for example, on roads or on water surfaces. It is also possible, however, to apply the method according to the present invention in a three-dimensional space. The method according to the present invention is thus also usable for air traffic and the motion of robots, or for use in underwater traffic.

Brief Description of the Drawings

Exemplified embodiments of the invention are depicted in the drawings and are explained in more detail in the description below.

Figure 1 is a block diagram of an apparatus according to the present invention;

Figure 2 is a flow chart of the method according to the present invention;

Figure 3 is a block diagram of the method according to the present invention;

Figure 4 is a diagram of the times required by various countermeasures for activation;

Figure 5 shows a first model for determining the hazard probability; and

Figure 6 shows a second model for determining the hazard probability.

Detailed Description of the Invention

It is particularly advantageous that the motion and the object class of the at least one second object are determined by a sensor apparatus, and the motion and object class of the first object are retrieved from at least one data source. This means that the other objects -- for example pedestrians, bicyclists, and other vehicles -- surrounding the first object — for example a vehicle -- are sensed using a sensor suite such as a pre-crash sensor suite, so that they can be classified and have motion parameters assigned to them. The own-vehicle values are retrieved from internal data sources, i.e. the vehicle type, current speed, direction, and a vehicle behavior model. Such sources are thus internal sensors and memories.

It is additionally advantageous that the motion of the first object is defined at least by way of its current position and its velocity. This yields a velocity vector that defines the relationship to the other objects. The motion of the other objects is defined at least by way of their current position. If stationary objects are involved, it is therefore not necessary to determine their velocity; only their position needs to be determined in order to determine the collision and hazard probabilities. For the first object, its longitudinal

and/or transverse acceleration and/or its rotation angle or variables derived therefrom and/or its steering angle can additionally be used as further parameters for definition of the motion. Environmental influences, i.e. the road condition or defined maximum speeds, and/or a respective vehicle behavior, can be taken into consideration by the corresponding model in determining the motion.

Lastly, it is also advantageous that as a function of the accident risk, an indication, i.e. a warning to the driver, and/or a message and/or at least one signal to an actuator suite, is generated. A control unit in a vehicle, or a restraint system, can preferably be used in the method according to the present invention. Motor vehicles, ships, aircraft, and robots are possible as objects.

Impact sensors are already in common use in motor vehicles. In addition, pre-crash sensors such as radar or ultrasound or video are also increasingly being used to monitor the vehicle surroundings. On the basis of this kind of all-around view, reversible restraint means such as belt tensioners, for example, can be used as a risk approaches. A more accurate analysis of the motion of the objects surrounding the vehicle is necessary, however, in order for suitable countermeasures to be applied in as prompt and situationally appropriate a manner as possible.

The present invention now proposes a method for determining an accident risk that analyzes surroundings data more accurately so that countermeasures can thus be applied in situationally appropriate fashion. In particular, a hazard probability, which also considers the immediate vicinity around an object, is calculated here in addition to a collision probability. The

method according to the present invention is not limited to utilization for road traffic, however; it can also be used for air traffic and shipping, in situations where robots are used, and for other applications.

Figure 1 shows an apparatus according to the present invention as a block diagram. A surroundings sensor suite 1 is connected to a processor 2. Sensor suite 1 transfers measured data to processor 2, which processes them. For that processing, processor 2 is connected via a data input/output to a memory 3. Processor 2 is connected via a first data output to an indicator 4. This indicator 4 serves to warn a driver, and is preferably embodied here as an optical indicator. Alternatively, it is possible for indicator 4, additionally or instead, to have a loudspeaker in order, also or alternatively, to warn the driver acoustically. A haptic warning by way of moving elements, in order to warn the driver by touch, is also conceivable here.

Processor 2 is connected via a second data output to a restraint system 5 that is used to protect the occupants in the event of an impact. Restraint system 5 encompasses restraint means such as a belt tensioner and airbags that are used for various body parts. The belt tensioners can be embodied pyrotechnically and/or reversibly, a reversible belt tensioner usually being operated by an electric motor. In addition to normal front airbags, side airbags, knee bags, and other airbags for special types of accident can be used.

Processor 2 uses data via an interior sensing system upon utilization of these restraint means 5. The result is that if use of the restraint means is possibly hazardous, that use is suppressed in order to prevent injuries resulting from such

restraint means. This applies, for example, when the person in question is located too close to a restraint means (e.g. is "out of position"), or when the person in question weighs so little that the force applied by an airbag might cause injuries. Pressure-based systems such as a seat mat or force sensors, or also wave-based interior sensor suites such as ultrasound, video, or infrared or high-frequency, can be used as the interior sensor suite. Processor 2 is connected via a third data output to an active steering aid 6 in order to assist the driver in avoiding a collision. It is possible for the processor to be connected only to restraint means 5 and/or to indicator 4 and/or to steering aid 6.

Restraint means 5 also include restraint means for the protection of pedestrians or bicyclists. These include raising the hood in order to protect such persons from impact against the engine block or windshield. The absorption characteristics of the bumper can also be appropriately adapted, and the vehicle or vehicle front can be raised or lowered in order to achieve improved crash compatibility. External airbags are also usable here in order to protect pedestrians and other traffic participants, for example in a vehicle/vehicle collision.

Processor 2 then evaluates the sensor signals of sensor suite 1 in order to combine them with a model — the dynamic vehicle model and optionally the driver model — that is loaded from memory 3. Data from data sources in the vehicle, temporarily stored in memory 3, are also needed in order to calculate the collision speed and approach speed. Those data include the own-vehicle type, speed, speed direction, acceleration in the vehicle, and also rotational acceleration expressed as rotation angles.

Using the collision and hazard probabilities, it is possible for processor 2 to calculate the accident risk for the current scenario as a function of the loaded data. Corresponding countermeasures are initiated as a function of that accident risk. A restraint system, or a system for acting on the vehicle behavior, can therefore then operate in situationally appropriate fashion.

Figure 2 shows, as a first flow chart, the method according to the present invention for determining an accident risk. In method step 7, a characterization of the motion of collision objects in the vehicle's surroundings is performed by sensor suite 1. This characterization is accomplished on the basis of the following parameters: current position, relative speed with respect to the observed object, and the longitudinal and transverse acceleration and rotational acceleration of the respective objects. An optional classification of the individual collision objects is furthermore performed by processor 2. This classification includes the vehicle type. That vehicle type is ascertained by sensor suite 1. Pattern recognition means can preferably be used in order to evaluate the sensor signals (e.g. video, radar, or ultrasound signals) and assign them to vehicle types. The motion parameters of the vehicle to be observed are also ascertained by way of sensor suite 1. As stated above, these include the vehicle position, vehicle speed, accelerations in the longitudinal and transverse directions, and rotational accelerations, all of which are derivable from such all-around view signals. Alternatively, it is possible for a communication to exist between the vehicles, making possible an exchange of such vehicle data.

In method step 8, the motion and object class are performed by retrieval from a memory, for example memory 3, in the vehicle in which the method according to the present invention is executing. The speed is known by way of the speedometer; longitudinal, transverse, and angular accelerations can be determined by way of internal acceleration sensors; the steering angle can be ascertained by a corresponding sensor. The object class, i.e. the vehicle model, can be stored in a memory. As an alternative to the speedometer, the speed can be determined by way of a satellite-assisted location signal such as GPS; radar sensors can also be used here in combination with inertial sensors.

From these data it is then possible, in method steps 9 and 10, to determine the collision probability and hazard probability. A dynamic model of the vehicle is used here. This dynamic model is dependent on the object class and can thus be loaded, for each vehicle, from memory 3. A driver behavior model can additionally be taken into consideration. This driver behavior model contains at least one model that assigns a probability to an action of the driver. In conjunction with the dynamic model of the vehicle, this enables the method according to the present invention to assign probabilities to all possible future states of the one vehicle and the other objects. A state encompasses at least the position, and optionally also the speed and orientation, as well as accelerations, rotation rates, and rotational accelerations.

In the simplest case only a driver behavior model is used, which is then the same for the own vehicle and the other objects. This model can be improved for the own vehicle using an adaptive model by using a driver observation sensor, or by observation of the driver's reaction in critical situations.

In method step 11, the accident risk is then estimated by the collision probability and hazard probability that have been determined. As a function of the accident risk, an initiation of countermeasures is then performed in method step 12. These countermeasures include activation of restraint systems, output of warnings to the driver, and driver assistance in avoiding collisions.

Figure 3 shows, in a block diagram, the execution of the method according to the present invention. Sensor suite 1 here has impact sensors 22, sensors for detecting vehicle dynamics 23, surroundings sensors 24, environment sensors 25, and driver observation sensors 26. It is possible to dispense with environment sensors 25 and driver observation sensors 26. Impact sensors 22 supply a signal that is used in block 27 to determine the accident risk and the activation of the actuator suite. Vehicle dynamics sensors 23 are used to track the motion of the own vehicle in block 31. These data then go into block 34, in which the collision probability and hazard probability are determined.

Surroundings sensors 24 supply their data to an object detection system 28. Object detection system 28 introduces the object detection data into a classification module 29 in order to classify the surrounding objects. Those objects are then, in the next block 30, tracked using data from the object classification and object detection systems. These tracking data of block 30 are then also used in block 34 to determine the collision probability and hazard probability, although vehicle dynamics model 32 and optionally driver behavior model 33 are also taken into account in this context. Data from environment sensors 25 go into vehicle dynamics model 32.

These sensors 25 supply data regarding the road, friction, and optionally temperature, as well as other parameters. Vehicle dynamics model 32 is then adapted therewith. Data from driver observation sensor 26 go into driver behavior model 33. This sensor 26 supplies data concerning the driver's attentiveness. Sensors that observe eyelid blinking, for example, can be used for this, although other vigilance sensors are also usable.

The collision and approach probabilities determined in block 34 are conveyed to module 27 in order to determine the accident risk. Data are also conveyed from block 27 to driver behavior model 33, however, in order to adapt the driver behavior model as a function of the driver's actions. Model 27 then performs an activation of actuator suite 35 as a function of the accident risk. This includes a restraint system 36; a collision avoidance system 37, e.g. by way of an automatic steering intervention or automatic braking action; a crash mitigation system 38, for example an adaptation of the bumper, raising/lowering of the vehicle front, vehicle/vehicle airbags, or collapsible front wheels in order encourage the colliding vehicles to slide apart; a pedestrian protection apparatus 39, for example a raising of the hood or pedestrian airbags; and a driver warning 40, which can be implemented by way of indicator 4 or a loudspeaker. A haptic output is possible here as well.

Figure 4 is a diagram showing the times required for activation of various countermeasures and, by way of example, the calculated probabilities of the time to collision. The collision probability and hazard probability are plotted on the ordinate 41; each can assume a maximum value of 1. The value 1 means that the collision or hazard will definitely occur within the predicted time.

The time before the collision needed to initiate a countermeasure is depicted on abscissa 42. This time requirement is described qualitatively in 43. Certain actions can be initiated even after the collision; other actions require milliseconds to seconds before the collision. Below the time axis, a variety of countermeasures are arranged on the time axis in accordance with their respective time requirements. The double arrows qualitatively show time spans for the beginning of activation. When that time span has elapsed, the countermeasure should no longer be activated.

Curve 44 shows, as a typical example, the collision probability rising with decreasing time until the collision, and curve 45 shows the similarly rising hazard probability. These profiles are typical of cases in which a collision later actually occurs.

The hazard probability is in principle greater than or equal to the collision probability, since the hazard, which means an excessively close pass, includes the instance of a collision.

Behind curves 44 and 45, and cross-hatched in each case, is the unavoidable uncertainty regarding the result for the collision and hazard probabilities. This uncertainty is caused, for example, by measurement errors. It tends to decrease as time proceeds, since the number of observations rises and the measurement errors likewise become small for a smaller object distance.

The earlier the countermeasure must be initiated, the greater the remaining probability at that point in time that the collision will not occur, i.e. that the countermeasure is

initiated unnecessarily. This may result, for example, from the fact that an escape opportunity still exists that an experienced driver might perceive.

Countermeasures that require a long activation time should consequently, if possible, cause no damage or only minor damage if improperly triggered.

The calculated values for the collision probability and hazard probability can be compared with thresholds. If the probability under consideration exceeds the threshold during the time period characterized by a double arrow, the corresponding countermeasure can then be activated. Activation also takes place if the threshold has already been exceeded as that time period is entered. The point in time for enabling activation is defined by the first intersection point 47 of curve 44 or 45 with curve 46. Threshold 46 need not necessarily be constant; thresholds that change over time are also usable.

Example: For the "Warn driver" countermeasure, curve 46 depicting the threshold for activation of a warning is drawn in by way of example. (Additional thresholds have been omitted for reasons of clarity.) If the hazard probability exceeds that threshold during the time period characterized by the double arrow, a warning is then outputted. Once that time period has elapsed, there is no further need to output a warning, since the driver no longer has sufficient time for a reaction.

For countermeasures such as, for example, warning the driver, which in turn cause no damage in normal circumstances, the hazard probability can be utilized for comparison with the

threshold in order to provide a warning even before the threat of a near miss. For other countermeasures, the collision probability is preferable. There is no difference in principle between the two probabilities; the collision probability merely represents a special case of the hazard probability.

Close to the origin of the diagram, the time needed in order to initiate a countermeasure is very short. Ultimately, the only action here is to modify the airbag triggering algorithm. If the time for initiation of countermeasures is somewhat greater, the pyrotechnic belt tensioner can then also still be used. If even more time is available, the reversible belt tensioner can also be used. With even more time, measures can be taken to enhance vehicle compatibility for a crash. As the next stage, it is possible to activate automatic braking. If even more time is available, automatic steering can also be taken into consideration. As the lowest action, the driver's reaction can be observed and he/she can be given acoustic or optical instructions as applicable.

Figure 5 shows schematically, from a bird's-eye perspective, how the collision probability can be determined. Own object 48 is here convoluted with second object 49, so that region 50 is created in the coordinate system of the own object. This involves placing the own object with its reference point "+" at the origin, and disposing second object 49 in multiple fashion around own object 48 in such a way that contact just occurs between objects 48 and 49. In multiple assemblage 51, reference point "x" of the second object describes a contour that represents the outline (edge) of region 50. This is the region that is taken into consideration for the collision probability. This region must be checked as to whether, at a future point in time, reference point "x" of the second object

will be located within it. If so, this corresponds to a collision. If such is not the case, then a collision does not exist.

Figure 5 represents a simplified and therefore less accurate variant for determining the region, since the objects here are assumed to be circular, which in turn results in a circular region as the convolution result. This simplification was dispensed with in Figure 6. Two oriented objects are depicted: own object 52 and second object 53. The convolution then results in region 55 depicted on the right side. Own object 52 is surrounded by other object 54, once again in contact, the orientation here being taken into consideration. Reference point "x" of the second object again describes the outline (edge) of region 55.

In order to determine the region that is taken into account for the hazard probability, the procedure is at first exactly the same as depicted in Figures 5 and 6. In addition, region 50 or 55 is also convoluted with a further region disposed in circular fashion around the origin. The radius of this circle is to be interpreted as the minimum safe distance between the objects. The sequence of the two convolutions is arbitrary, i.e. without changing the final result, it is possible instead to convolute one of the objects with the circular region and then to convolute the intermediate result with the other object.

The probabilities are determined by calculating probability density functions and integrating them, a determination being made on the basis of region 50 or 55, for each combination of the residence locations of the two objects (a residence location being determined in each case by the position of the

object's reference point), as to whether or not a collision or hazard exists.

A quantization is used for the residence locations, the sampling being dense for short prediction times and more widely spaced for longer prediction times.

The non-action course is the course taken by the vehicle if no action is taken by the driver in order to modify the vehicle parameters, i.e. the speed and the acceleration vector. That course therefore continues to be followed if no changes are made by the driver in terms of steering or braking or acceleration. This typically occurs when the driver has not yet recognized the threatening situation or has assessed it incorrectly. The collision probability of the non-action course that is prepared by the driver behavior model is generally much greater than the probabilities of other possible courses. It is therefore advisable to model this non-action course separately, specifically with a greater precision, so that the remaining probability can then be distributed among all the other courses that the driver can take. These other courses are caused by braking, steering, or acceleration. The method according to the present invention for determining the accident risk, in which the collision probability and hazard probability are determined, depend on three parameters:

1) The initial states, made available by way of real-time sensor information, of the first and the further objects.

2) A vehicle dynamics model is used to predict future positions of the own vehicle and the other objects, taking into account the real-time sensor information.

3) A driver behavior model is used to assign probabilities of possible future positions of the own vehicle and the other objects.

The quality of the method according to the present invention can be enhanced by improving these input parameters. For example, using the object class as an input parameter increases the accuracy of the collision and hazard probabilities. This is because physical boundaries of the individual objects reduce the number of possible future positions of the respective object.

Instead of considering vehicle dynamics models, it is also possible to select general dynamics models that incorporate pedestrians as well. This also applies to the concept of the driver behavior model, which can be expanded to a general behavior model and also takes pedestrians into consideration.

ABSTRACT

A method for determining an accident risk of a first object with at least one second object is proposed, a collision probability and a hazard probability of the at least one second object being determined in a predefined region around the first object, the collision probability and the hazard probability being determined as a function of motions and object classes of the first and the at least one second object. The accident risk is then determined as a function of the collision probability and the hazard probability.

303127

[10191/3675]

COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT,** and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No. _________ on _________, 20__ and was amended by the Preliminary Amendment filed on ____________, 20__.

[x] was filed as PCT International Application Number PCT/DE03/01409, on the 2nd day of May, 2003.

[x] an English translation of which is filed herewith.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S)
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119

Country : Federal Republic of Germany

Application No. : 102 57 842.7

Date of Filing: 11 December 2002

Priority Claimed
Under 35 U.S.C. § 119 : [x] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR
PCT INTERNATIONAL APPLICATIONS
DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120

U.S. APPLICATIONS

Number : 60/378,444

Filing Date : May 7, 2002

PCT APPLICATIONS
DESIGNATING THE U.S.

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.
(List name(s) and registration number(s)):

Richard L. Mayer, Reg. No. 22,490
Gerard A. Messina, Reg. No. 35,952

All correspondence should be sent to:

Richard L. Mayer, Esq.
Kenyon & Kenyon
One Broadway
New York, New York 10004

CUSTOMER NO. 26646

Telephone No.: (212) 425-7200
Facsimile No.: (212) 425-5288

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Full name of inventor: **Stephan SIMON**

Inventor's signature ______________ Date 16. March 2005

Citizenship Federal Republic of Germany

Residence Pfarrlandstr. 10
31079 Sibbesse
Federal Republic of Germany

Post Office Address Same as above

Full name of inventor: **Brad IGNACZAK**

Inventor's signature ____________________ Date 6. April. 2005

Citizenship U.S.A.

Residence 1658 Heritage Drive
Canton, MI 48188
U.S.A.

Post Office Address Same as above

Full name of inventor: **Robert LYONS**

Inventor's signature ________________ Date 6.APR.2005

Citizenship U.S.A.

Residence 9296 Wild Oaks Circle
South Lyon, MI 48178
U.S.A.

Post Office Address Same as above

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/DE 03/0[redacted]9

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTA[redacted]ES
IPK 7 G01S13/93

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 7 G01S

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

EPO-Internal, PAJ, INSPEC

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	US 6 085 151 A (BRUCE MICHAEL P ET AL) 4. Juli 2000 (2000-07-04) ~~Zusammenfassung; Abbildung 9~~ (Abstract; figure 9) ~~Spalte 11, Zeile 33 – Zeile 52~~ (Column 11, line 33 - line 52) ~~Spalte 13, Zeile 20 – Zeile 57~~ (Column 13, line 20 - line 57) ---	1,10,11
A	US 5 572 428 A (ISHIDA SHINNOSUKE ET AL) 5. November 1996 (1996-11-05) ~~Zusammenfassung; Abbildungen 15-19~~ (Abstract; figures 15-19) ~~Spalte 10, Zeile 8 – Spalte 11, Zeile 8~~ (Column 10, line 8 - col. 11, line 8) ---	1,10,11
A	US 6 256 565 B1 (YANAGI EIJI ET AL) 3. Juli 2001 (2001-07-03) ~~Zusammenfassung; Abbildungen 2,9~~ (Abstract; figures 2, 9) ~~Spalte 5, Zeile 53 – Spalte 6, Zeile 5~~ (Column 5, line 53 - col. 6, line 5) ~~Spalte 9, Zeile 1 – Spalte 10, Zeile 5~~ (Column 9, line 1 - col. 10, line 5) -----	1,10,11

☐ Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

☒ Siehe Anhang Patentfamilie

° Besondere Kategorien von angegebenen Veröffentlichungen :
"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist
"E" älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist
"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Recherchenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)
"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht
"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist

"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist
"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann allein aufgrund dieser Veröffentlichung nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden
"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren anderen Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist
"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
12. September 2003	19/09/2003

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Niemeijer, R

EV 320194842 US

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie			Datum der Veröffentlichung
US 6085151	A	04-07-2000	EP	0954758	A1	10-11-1999
			JP	2002511922	T	16-04-2002
			WO	9832030	A1	23-07-1998
US 5572428	A	05-11-1996	JP	2799375	B2	17-09-1998
			JP	7104062	A	21-04-1995
US 6256565	B1	03-07-2001	JP	2001055105	A	27-02-2001

PCT

ANTRAG

Der Unterzeichnete beantragt, daß die vorliegende internationale Anmeldung nach dem Vertrag über die internationale Zusammenarbeit auf dem Gebiet des Patentwesens behandelt wird

Vo[m] [A]nmeldeamt auszufüllen

Internationales Aktenzeichen

Internationales Anmeldedatum

Name des Anmeldeamts und "PCT International Application"

Aktenzeichen des Anmelders oder Anwalts *(falls gewünscht)* *(max. 12 Zeichen)* R. 303127 Dr. Vogt/Da

Feld Nr. I BEZEICHNUNG DER ERFINDUNG

Verfahren zur Bestimmung von Kollisionswahrscheinlichkeiten

Feld Nr. II ANMELDER ☐ Diese Person ist gleichzeitig Erfinder

Name und Anschrift *(Familienname, Vorname; bei juristischen Personen vollständige amtliche Bezeichnung. Bei der Anschrift sind die Postleitzahl und der Name des Staats anzugeben. Der in diesem Feld in der Anschrift angegebene Staat ist der Staat des Sitzes oder Wohnsitzes des Anmelders, sofern nachstehend kein Staat des Sitzes oder Wohnsitzes angegeben ist.)*

ROBERT BOSCH GMBH
Postfach 30 02 20
70442 Stuttgart
Bundesrepublik Deutschland (DE)

Telefonnr.: 0711/811-33135

Telefaxnr.: 0711/811-331 81

Fernschreibnr.:

Registrierungsnr. des Anmelders beim Amt

Staatsangehörigkeit (Staat): DE | Sitz oder Wohnsitz (Staat): DE

Diese Person ist Anmelder für folgende Staaten: ☐ alle Bestimmungsstaaten ☒ alle Bestimmungsstaaten mit Ausnahme der Vereinigten Staaten ☐ nur die Vereinigten Staaten von Amerika ☐ die im Zusatzfeld angegebenen Staaten

Feld Nr. III WEITERE ANMELDER UND/ODER (WEITERE) ERFINDER

Name und Anschrift *(Familienname, Vorname; bei juristischen Personen vollständige amtliche Bezeichnung. Bei der Anschrift sind die Postleitzahl und der Name des Staats anzugeben. Der in diesem Feld in der Anschrift angegebene Staat ist der Staat des Sitzes oder Wohnsitzes des Anmelders, sofern nachstehend kein Staat des Sitzes oder Wohnsitzes angegeben ist.)*

SIMON, Stephan
Pfarrlandstr. 10
31079 Sibbesse
DE

Diese Person ist

☐ nur Anmelder

☒ Anmelder und Erfinder

☐ nur Erfinder *(Wird dieses Kästchen angekreuzt, so sind die nachstehenden Angaben nicht nötig.)*

Registrierungsnr. des Anmelders beim Amt

Staatsangehörigkeit (Staat): DE | Sitz oder Wohnsitz (Staat): DE

Diese Person ist Anmelder für folgende Staaten: ☐ alle Bestimmungsstaaten ☐ alle Bestimmungsstaaten mit Ausnahme der Vereinigten Staaten ☒ nur die Vereinigten Staaten von Amerika ☐ die im Zusatzfeld angegebenen Staaten

☒ Weitere Anmelder und/oder (weitere) Erfinder sind auf einem Fortsetzungsblatt angegeben.

Feld Nr. IV ANWALT ODER GEMEINSAMER VERTRETER; ZUSTELLANSCHRIFT

Die folgende Person wird hiermit bestellt/ist bestellt worden, um für den (die) Anmelder vor den zuständigen internationalen Behörden in folgender Eigenschaft zu handeln als: ☐ Anwalt ☒ gemeinsamer Vertreter

Name und Anschrift *(Familienname, Vorname; bei juristischen Personen vollständige amtliche Bezeichnung Bei der Anschrift sind die Postleitzahl und der Name des Staats anzugeben)*

ROBERT BOSCH GMBH
Postfach 30 02 20
70442 Stuttgart
Bundesrepublik Deutschland (DE)

Telefonnr.:

Telefaxnr.:

Fernschreibnr:

Registrierungsnr. des Anmelders beim Amt

☐ **Zustellanschrift:** Dieses Kästchen ist anzukreuzen, wenn kein Anwalt oder gemeinsamer Vertreter bestellt ist und statt dessen im obigen Feld eine spezielle Zustellanschrift angegeben ist.

Feld Nr. VI PRIORITÄTSANSPRUCH

Anmeldedatum der früheren Anmeldung *(Tag/Monat/Jahr)*	Aktenzeichen der früheren Anmeldung	Ist die frühere Anmeldung eine: nationale Anmeldung: Staat	Regionale Anmeldung: * Regionales Amt	internationale Anmeldung: Anmeldeamt
Zeile (1) 07. Mai 2002 (07.05.02)	60/378444	Vereinigte Staaten von Amerika		
Zeile (2) 11. Dezember 2002 (11.12.02)	102 57 842.7	Bundesrepublik Deutschland		
Zeile (3)				
Zeile (4)				
Zeile (5)				

☐ Weitere Prioritätsansprüche sind im Zusatzfeld angegeben

Das Anmeldeamt wird ersucht, eine beglaubigte Abschrift der oben bezeichneten früheren Anmeldung(en) zu erstellen und dem internationalen Büro zu übermitteln *(nur falls die frühere Anmeldung(en) bei dem Amt eingereicht worden ist (sind), das für die Zwecke dieser internationalen Anmeldung Anmeldeamt ist)*

☐ sämtliche Zeilen ☒ Zeile (1) ☒ Zeile (2) ☐ Zeile (3) ☐ Zeile (4) ☐ Zeile (5) ☐ weitere, siehe Zusatzfeld

** Falls es sich bei der früheren Anmeldung um eine ARIPO-Anmeldung handelt, geben Sie mindestens einen Staat an, der Mitgliedstaat der Pariser Verbandsübereinkunft zum Schutz des gewerblichen Eigentums oder Mitglied der Welthandelsorganisation ist und für den oder das die frühere Anmeldung eingereicht wurde*

Feld Nr. VII INTERNATIONALE RECHERCHENBEHÖRDE

Wahl der internationalen Recherchenbehörde (ISA) *(falls zwei oder mehr als zwei internationale Recherchenbehörden für die Ausführung der internationalen Recherche zuständig sind, geben Sie die von Ihnen gewählte Behörde an; der Zweibuchstaben-Code kann benutzt werden)*:
ISA/...

Antrag auf Nutzung der Ergebnisse einer früheren Recherche: Bezugnahme auf diese frühere Recherche *(falls eine frühere Recherche bei der internationalen Recherchenberörde beantragt oder von ihr durchgeführt worden ist)*:
Datum *(Tag/Monat/Jahr)*: Aktenzeichen Staat (oder regionales Amt)

Feld Nr. VIII ERKLÄRUNGEN

Die Felder Nr. VIII (i) bis (v) enthalten die folgenden Erklärungen *(Kreuzen Sie unten die entsprechenden Kästchen an und geben Sie in der rechten Spalte für jede Erklärung deren Anzahl an)*:			Anzahl der Erklärungen
☐	Feld Nr. VIII (i)	Erklärung hinsichtlich der Identität des Erfinders :	
☐	Feld Nr. VIII (ii)	Erklärung hinsichtlich der Berechtigung des Anmelders, zum Zeitpunkt des internationalen Anmeldedatums, ein Patent zu beantragen und zu erhalten :	
☐	Feld Nr. VIII (iii)	Erklärung hinsichtlich der Berechtigung des Anmelders, zum Zeitpunkt des internationalen Anmeldedatums, die Priorität einer früheren Anmeldung zu beanspruchen :	
☐	Feld Nr. VIII (iv)	Erfindererklärung (nur im Hinblick auf die Bestimmung der Vereinigten Staaten von Amerika) :	
☐	Feld Nr. VIII (v)	Erklärung hinsichtlich unschädlicher Offenbarungen oder Ausnahmen von der Neuheitsschädlichkeit :	

Feld Nr. IX KONTROLLISTE; E... EICHUNGSSPRACHE

Diese internationale Anmeldung enthält
(a) **auf Papier**, die folgende Anzahl Blätter:

Antrag (inklusive Erklärungsblätter)	: 5
Beschreibung (ohne Sequenzprotokolle und/oder Diesbezügliche Tabellen)	: 14
Ansprüche	: 2
Zusammenfassung	: 1
Zeichnungen	: 4
Teilanzahl	:
Sequenzprotokolle	:
Diesbezügliche Tabellen *(für beide, Anzahl der Blätter, soweit auf Papier eingereicht wird, unabhängig davon, ob zusätzlich auch in computerlesbarer Form eingereicht wird; siehe unter (c))*	:
Gesamtanzahl	: 26

(b) ausschließlich in computerlesbarer Form (Abschnitt 801 (a)(i))
(i) ☐ Sequenzprotokolle
(ii) ☐ diesbezügliche Tabellen

(c)) auch in computerlesbarer Form (Abschnitt 801 (a)(ii))
(i) ☐ Sequenzprotokolle
(ii) ☐ diesbezügliche Tabellen

Art und Anzahl der Datenträger (Diskette, CD-ROM, CD-R oder sonstige), auf denen sich befinden :
(i) ☐ Sequenzprotokolle
(ii) ☐ diesbezügliche Tabellen

(zusätzlich eingereichte Kopien unter Punkt 9(ii) in der rechten Spalte angeben):
....

... internationalen Anmeldung liegen die folgenden Anzahl ... gen bei *(kreuzen Sie die entsprechenden Kästchen an und geben Sie in der rechten Spalte jeweils die Anzahl der beiliegenden Exemplare an)*

		Anzahl
1. ☒	Blatt für die Gebührenberechnung	: 1
2. ☐	Original einer gesonderten Vollmacht	:
3. ☐	Original einer allgemeinen Vollmacht	:
4. ☐	Kopien der allgemeinen Vollmacht; Aktenzeichen (falls vorhanden)	:
5. ☐	Begründung für das Fehlen einer Unterschrift	:
6. ☐	Prioritätsbeleg(e), in Feld VI durch folgende Zeilennummer gekennzeichnet:	:
7. ☐	Übersetzung der internationalen Anmeldung in die folgende Sprache:	:
8. ☐	Gesonderte Angaben zu hinterlegten Mikroorganismen oder biologischem Material	:
9. ☐	Sequenzprotokolle in computerlesbarer Form (Art und Anzahl der Datenträger)	:
	(i) ☐ Kopie ausschließlich für die Zwecke der internationalen Recherche nach Regel 13*ter* (und nicht als Teil der internationalen Anmeldung) :	:
	(ii) ☐ *(nur falls Feld (b)(i) oder (c)(ii) in der linken Spalte angekreuzt wurden)* zusätzliche Kopien einschließlich, soweit zutreffend, einer Kopie für die Zwecke der internationalen Recherche nach Regel 13*ter* :	:
	(iii) ☐ zusammen mit entsprechender Erklärung, daß die Kopie(n) mit dem in der linken Spalte aufgeführten Sequenzprotokollen identisch ist (sind) :	:
10. ☐	☐ Tabellen in computerlesbarer Form im Zusammenhang mit Sequenzprotokollen *(Art und Anzahl der Datenträger)*	:
	(i) ☐ Kopie ausschließlich für die Zwecke der internationalen Recherche nach Abschnitt 802(b-*quater*) (und nicht als Teil der internationalen Anmeldung) :	:
	(ii) ☐ *(nur falls Felder (b)(ii) oder (c)(ii) in der linken Spalte angekreuzt wurden)* zusätzliche Kopien einschließlich, soweit zutreffend, einer Kopie für die Zwecke der internationalen Recherche nach Abschnitt 802(b-*quater*) :	:
	(iii) ☐ zusammen mit entsprechender Erklärung, daß die Kopie(n) mit dem in der linken Spalte aufgeführten Tabellen identisch ist (sind)	:
11. ☒	Sonstige *(einzeln aufführen)*: Abschrift(en) für Prioritätsbeleg(e)	: 1

Abbildung der Zeichnungen, die mit der Zusammenfassung veröffentlicht werden soll (Nr.): 3

Sprache, in der die internationale Anmeldung eingereicht wird: Deutsch

Feld Nr. IX UNTERSCHRIFT DES ANMELDERS ODER DES ANWALTS

Der Name jeder unterzeichnenden Person ist neben der Unterschrift zu wiederholen, und es ist anzugeben, sofern sich dies nicht eindeutig aus dem Antrag ergibt, in welcher Eigenschaft die Person unterzeichnet.

ROBERT BOSCH GMBH
Nr. 35/71 AV Vogt
Dr. Vogt

Stephan SIMON
Robert LYONS

Brad IGNACZAK

Vom Anmeldeamt auszufüllen

1. Datum des tatsächlichen Eingangs dieser internationalen Anmeldung	2. Zeichnungen
3. Geändertes Eingangsdatum aufgrund nachträglich, jedoch fristgerecht eingegangener Unterlagen oder Zeichnungen zur Vervollständigung dieser internationalen Anmeldung:	☐ eingegangen:
4. Datum des fristgerechten Eingangs der angeforderten Richtigstellung nach Artikel 11(2) PCT:	☐ nicht eingegangen:
5. Internationale Recherchenbehörde *(falls zwei oder mehr zuständig sind)* ISA/	6. ☐ Übermittlung des Recherchenexemplars bis zur Zahlung der Recherchengebühr aufgeschoben

Vom Internationalen Büro auszufüllen

Datum des Eingangs des Aktenexemplars
Beim Internationalen Büro:

Dieses Blatt ist nicht Teil und zählt nicht als Blatt der internationalen Anmeldung

PCT

BLATT FÜR DIE GEBÜHRENBERECHNUNG

Anhang zum Antrag

Aktenzeichen des Anmelders oder Anwalts: R. 303127 Vogt/Da

Vom Anmeldeamt auszufüllen

Internationales Aktenzeichen

Eingangsstempel des Anmeldeamts

Anmelder: Robert Bosch GmbH
Postfach 30 02 20, D-70442 Stuttgart

BERECHNUNG DER VORGESCHRIEBENEN GEBÜHREN

1. ÜBERMITTLUNGSGEBÜHR .... 90,-- **T**

2. RECHERCHENGEBÜHR .... 945,-- **S**

   Die internationale Recherche ist durchzuführen von ________________

   (Sind zwei oder mehr Internationale Recherchenbehörden für die internationale Recherche zuständig, ist der Name der Behörde anzugeben, die die internationale Recherche durchführen soll.)

3. INTERNATIONALE GEBÜHR

   Grundgebühr

   Soweit Punkt (b) von Feld Nr. IX Anwendung findet, **Teilanzahl an Blättern**
   Soweit Punkt (b) von Feld Nr. IX keine Anwendung findet, **Gesamtanzahl an Blättern**

   b1 umfaßt die ersten 30 Blätter 444,-- **b1**

   b2 ______ x 10,-- = ______ **b2**
   Anzahl der Blätter über 30 — Zusatzgebühr

   b3 zusätzliche Komponente (nur falls der Sequenzprotokollteil der Beschreibung in computerlesbarer Form nach Abschnitt 801(a)(i), oder sowohl in dieser Form als auch auf Papier nach Abschnitt 801(a)(ii) eingereicht wird):

   ______ x ______ = ______ **b3**
   Zusatzgebühr

   Addieren Sie die in Feld b1, b2 und b3 eingetragenen Beträge, und tragen Sie die Summe in Feld B ein .... 444,-- **B**

   Bestimmungsgebühren alle

   Die internationale Anmeldung enthält Y Bestimmungen.

   5 x 96,-- = 480,-- **D**
   Anzahl der zu zahlenden Bestimmungsgebühren *(maximal 5)* — Bestimmungsgebühr

   Addieren Sie die in Feld B und D eingetragenen Beträge, und tragen Sie die Summe in Feld I ein .... 924,-- **I**

   (Anmelder aus einigen Staaten haben Anspruch auf eine Ermäßigung der internationalen Gebühr um 75%. Hat der Anmelder (oder haben alle Anmelder) einen solchen Anspruch, so beträgt der in Feld I einzutragende Gesamtbetrag 25% der Summe der in Feld B und D eingetragenen Beträge.)

4. GEBÜHR FÜR PRIORITÄTSBELEG *(ggf)* .... 20,-- **P**

5. GESAMTBETRAG DER ZU ZAHLENDEN GEBÜHREN.
   Addieren Sie die in den Feldern T, S, I und P eingetragenen Beträge, und tragen Sie die Summe in das nebenstehende Feld ein .... 1979,-- INSGESAMT

☐ Die Bestimmungsgebühren werden jetzt noch nicht gezahlt

ZAHLUNGSWEISE

☒ Abbuchungsauftrag (siehe unten) ☐ Postanweisung ☐ Barzahlung ☐ Kupons
☐ Scheck ☐ Bankwechsel ☐ Gebührenmarken ☐ Sonstige *(einzeln angeben)*:

ABBUCHUNGSAUFTRAG- bzw. GUTSCHREIBUNGSAUFTRAG
(diese Zahlungsweise gibt es nicht bei allen Anmeldeämtern

☒ Ermächtigung, den vorstehend angegebenen Gesamtbetrag der Gebühren abzubuchen.

☒ *(dieses Kästchen darf nur angekreuzt werden, wenn die Vorschriften des Anmeldeamts über laufende Konten dieses Verfahren erlauben)* Ermächtigung, Fehlbeträge oder Überzahlungen des vorstehend angegebenen Gesamtbetrags der Gebühren meinem laufenden Konto zu belasten bzw. gutzuschreiben.

☒ Ermächtigung, die Gebühr für die Ausstellung des Prioritätsbeleges abzubuchen.

Anmeldeamt: RO/ DPMA

Kontonummer: 346 248 100, Dresdner Bank AG

Datum: 29.04.2003

Name: ROBERT BOSCH GMBH

Unterschrift: Vogt

Nr. 35/71 AV Dr. Vogt

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE			
INFORMATION DISCLOSURE STATEMENT		Docket Number **10191/3675**	
Application Number **To Be Assigned**	Filing Date **Filed Herewith**	Examiner **To Be Assigned**	Art Unit **To Be Assigned**
Title **METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT**		Applicant(s) **Stephan SIMON et al.**	

Address to:
Mail Stop PCT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

1. In accordance with the duty of disclosure under 37 C.F.R. § 1.56 and in conformance with the procedures of 37 C.F.R. §§ 1.97 and 1.98 and M.P.E.P. § 609, attorneys for Applicant(s) hereby bring the following reference(s) to the attention of the Examiner. The reference(s) are listed on the attached modified PTO Form No. 1449. It is respectfully requested that the information be expressly considered during the prosecution of this application, and that the reference(s) be made of record therein and appear among the "References Cited" on any patent to issue therefrom.

2. A copy of each patent, publication or other information listed on the modified PTO form 1449 is enclosed, except as otherwise indicated on the modified PTO form 1449.

Dated: 5/4/05

By: By [illegible] Reg No 35,952
Richard L. Mayer (Reg. No. 22,490)

KENYON & KENYON
One Broadway
New York, N.Y. 10004
(212) 425-7200 (telephone)
(212) 425-5288 (facsimile)

CUSTOMER NO. 26646

Express Mail No.: EV 320194842 US
NY01 706278 v1

INFORMATION DISCLOSURE STATEMENT BY APPLICANTS PTO FORM 1449	ATTY. DOCKET NO. **10191/3675**	SERIAL NO. **To Be Assigned**
	APPLICANT(s) **Stephan SIMON et al.**	
	FILING DATE **Filed Herewith**	GROUP **To Be Assigned**

U. S. PATENT DOCUMENTS

EXAMINER INITIAL	PATENT NUMBER	PATENT DATE	NAME	CLASS	SUBCLASS	FILING DATE
	* 6,085,151	July 4, 2000	Michael et al.			
	* 5,572,428	November 5, 1996	Shinnosuke et al.			
	* 6,256,565	July 3, 2001	Yanagi Eiji et al.			

* Copy of reference is not enclosed because reference is cited in Search Report (copy of reference provided by International Searching Authority).

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB-CLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS

EXAMINER INITIAL		AUTHOR, TITLE, DATE, PERTINENT PAGES, ETC.

EXAMINER	DATE CONSIDERED
EXAMINER: Initial if citation considered, whether or not citation is in conformance with M.P.E.P. 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

10191/3675

FORM PTO-1585

RECORDATION FORM COVER SHEET

U.S. DEPARTMENT OF COMMERCE

Patent and Trademark Office

PATENTS ONLY

To Mail Stop Assignment Recordation Service, Director or the U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450: Please record the attached original documents or copy thereof

1. Name of conveying party(ies): **Stephan SIMON; Brad IGNACZAK; and Robert LYONS** Additional name(s) of conveying parties attached? ☐ Yes ☑ No	2. Name and address of receiving party(ies) Name: **Robert Bosch GmbH** Internal Address: ________ Street Address: **Postfach 30 02 20** City: **D-70442 Stuttgart** State: **Federal Republic of Germany** ZIP: ____ Additional name(s) & address(es) attached? ☐ Yes ☑ No
3. Nature of conveyance: ☑ Assignment ☐ Merger ☐ Security Agreement ☐ Change of Name ☐ Other: ________ Execution dates: March 16, April 6,April 6, 2005.	
4. Application numbers or patent numbers: Date application executed: March 16,April 6,April 6, 2005.	
A. Patent Application: **To be assigned**	B. Patent No.(s)
Additional Numbers attached? ☐ Yes ☑ No	
5. Name and address of party to whom correspondence concerning document should be mailed: Name: Richard L. Mayer Internal Address: KENYON & KENYON Street Address: One Broadway City: New York State: New York ZIP: 10004	6. Total number of applications and patents involved: **1**
	7. Total fee (37 C.F.R. 3.41) .... **$ 40.00** ☐ Enclosed ☑ Authorized to be charged to deposit account
	8. Deposit account number: 11-0600

DO NOT USE THIS SPACE

9. Statement and signature. *To the best of my knowledge and belief, the foregoing information is true and correct and any attached copy is a true copy of the original document.*

Richard L. Mayer (Reg. No. 22,490) Name of Person Signing	Ignacio Reg No 35,952 Signature	5/4/05 Date

Total Number of pages including cover sheet, attachments and document: **6**

OMB No. 0651-0011 (exp. 4/94)

Do not detach this portion

Mail documents to be recorded with required cover sheet information to:

Mail Stop Assignment Recordation Services
Director or the U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

303127

[10191/3675]

ASSIGNMENT

WHEREAS, we,

Stephan SIMON
Pfarrlandstr. 10
31079 Sibbesse
Federal Republic of Germany
Citizenship: Federal Republic of Germany

Brad IGNACZAK
1658 Heritage Drive
Canton, MI 48188
U.S.A.
Citizenship: U.S.A.

and

Robert LYONS
9296 Wild Oaks Circle
South Lyon, MI 48178
U.S.A.
Citizenship: U.S.A.

have made inventions and discoveries in **METHOD FOR DETERMINING AN ACCIDENT RISK OF A FIRST OBJECT WITH AT LEAST ONE SECOND OBJECT**,the specification of which was filed as PCT International Application No. PCT/DE03/01409, on May 2, 2003, and

WHEREAS **ROBERT BOSCH GMBH**, having a place of business at **Postfach 30 02 20, 70442 Stuttgart, Federal Republic of Germany**, and who, together with its successors and assigns, is hereinafter called "Assignee," is desirous of acquiring the title, rights, benefits, and privileges hereinafter recited,

NOW, THEREFORE, for valuable consideration furnished by Assignee to us, receipt and sufficiency of which we hereby acknowledge, we hereby, without reservations:

1. Assign, transfer, and convey to Assignee the entire right, title, and interest in and to said inventions and discoveries, said application for Letters Patent of the United States of America, any and all other applications for Letters Patent on said inventions and discoveries, including all divisional, renewal, substitute, and continuation applications based in whole or in part upon said inventions or discoveries, or upon said applications, and any and all Letters Patent, reissues, and extensions of Letters Patent granted for said inventions and discoveries or upon said applications, and every priority right that is or may be predicated upon or arise from said inventions, said discoveries, said applications, and said Letters Patent.

2. Authorize Assignee to file patent applications in any or all countries for any or all of said inventions and discoveries in our names or in the name of Assignee

or otherwise as Assignee may deem advisable, under an International Convention or otherwise.

3. Authorize and request the Commissioner of Patents and Trademarks of the United States of America and the empowered officials of all other governments to issue or transfer all said Letters Patent to Assignee, as assignee of the entire right, title, and interest therein or otherwise as Assignee may direct.

4. Warrant that we have not conveyed to others any right, title, or interest in said inventions, discoveries, applications, or patents or any license to use the same or to make, use, or sell anything embodying or utilizing any of said inventions or discoveries; that we have good right to assign the same to Assignee without encumbrance; and that we are aware of no claim to the contrary.

5. Bind our heirs, legal representatives, and assigns, as well as ourselves, to do, upon Assignee's request and at Assignee's expense, but without additional consideration to us or them, all acts reasonably serving to assure that the said inventions and discoveries, the said patent applications, and the said Letters Patent shall be held and enjoyed by Assignee as fully and entirely as the same could have been held and enjoyed by us, our heirs, legal representatives, and assigns if this assignment had not been made; and particularly to execute and deliver to Assignee all lawful application documents including petitions, specifications, and oaths, and all assignments, disclaimers, and lawful affidavits in form and substance as may be requested by Assignee; to communicate to Assignee all facts known to us relating to said inventions and discoveries or the history thereof; to furnish Assignee with any and all documents, photographs, models, samples, and other physical exhibits in our control or in the control of our heirs, legal representatives, or assigns which may be useful for establishing the facts of our conceptions, disclosures, and reduction to practice of said inventions and discoveries; and to testify to the same in any interference, arbitration, or litigation.

IN TESTIMONY WHEREOF, I have hereunto set my hand and seal this 16 day of March, 2005

Stephan SIMON

IN TESTIMONY WHEREOF, I have hereunto set my hand and seal this 6 day of April, 2005.

Brad IGNACZAK

IN TESTIMONY WHEREOF, I have hereunto set my hand and seal this 6 day of APRIL, 2005.

Robert LYONS